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# AN ECOLOGICAL EVALUATION OF BIG GAME RIDGE

GEORGE E. GRUELL



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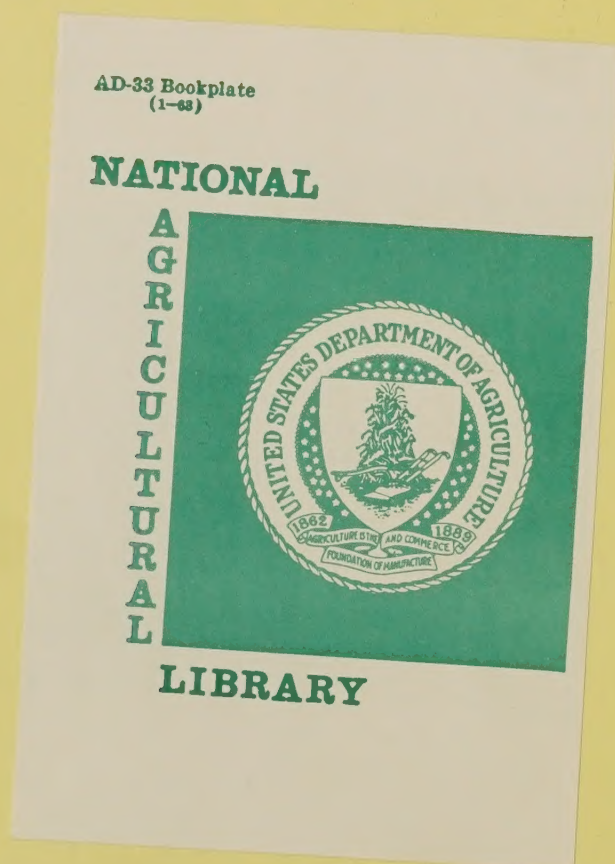
## THE AUTHOR

George Gruell is a "working biologist" for the Teton National Forest in Jackson Hole, Wyoming. His experience in management of wildlife habitat is leading to significant publications in the field.

Mr. Gruell graduated from Humboldt State College in 1953 with a Bachelor of Science in wildlife management. He worked for the Nevada Fish and Game Department as a big game biologist through 1958. He worked extensively on mule deer migration, a work which was documented in the *Journal of Wildlife Management*, "Movements of Mule Deer in Northeastern Nevada".

In 1962 he joined the Forest Service, as a wildlife biologist on the Humboldt National Forest in Nevada where his work centered on condition and trend of deer ranges.

Moving to the Teton National Forest in 1967, Mr. Gruell's work, in addition to that described in this publication, has focused primarily on plant succession and its relationship to elk winter and summer ranges, evaluation of the role of fire in plant succession, and its application to wildlife habitat. He has co-authored a paper on "The Ecological Role of Fire in Jackson Hole".



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BIG GAME RIDGE**

**BY**

**GEORGE E. GRUELL**

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**APRIL 1973**

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## ABSTRACT

A study of the ecology of Big Game Ridge within the Teton Wilderness of northwestern Wyoming was carried out from June 1967 - September 1971. Interpretations differ from previous studies and fail to substantiate conclusions that overutilization and trampling by elk were responsible for a deterioration of grazable vegetation and accelerated soil erosion.

A historical review of the literature failed to substantiate certain premises concerning the history of the Jackson Hole elk - notably that the areas under study were not historical elk range and that populations are presently higher than historical numbers because of supplemental feeding. The summer elk herd and vegetative cover evolved together. It is highly probable that prior to modern man's intrusion, wide fluctuations in the elk population, a short season of elk use of subalpine areas and variable elk distribution influenced by seasonal weather differences interacted as a built-in safeguard against overuse of the forage resource.

Current forage utilization and impact are not causing a deterioration in the plant cover. Where ground cover is sparse, it is essentially a function of poor site potential traceable to inadequate soil moisture or harsh snowbank microclimates. Photographic evidence suggests that the vegetative trend has been one of improvement in the past 56 years. Photos from adjacent localities also support this interpretation.

Geologic erosion occurs on the area and does not appear to have been directly or indirectly accelerated by modern man's influence. The primary biotic agent in geologic erosion has been the pocket gopher. Evidence from this and other studies suggest that high populations of pocket gophers have been the major contributor to soil disturbance since pristine time. Periodically high population levels do not represent departures from natural condition. They instead reflect the occurrence of desirable tall forb habitat.

# INTRODUCTION

Big Game Ridge is a high mountain summer range for elk (*Cervus canadensis nelsoni*) in the Teton Wilderness of the Teton National Forest and in Yellowstone National Park (Fig. 1). The Forest portion of this ridge has been subject to considerable interest and controversy over the past several decades. The locality has been observed and studied by a large number of people. However, until recently the ecology has not been studied on a systematic basis over an extended time period. Conclusions from previous studies were largely drawn following reconnaissance of only a few days.

Particular attention was focused on the area following the publication, "Watershed and Range Conditions on Big Game Ridge and Vicinity - Teton National Forest, Wyoming", (Croft and Ellison, 1960). Written following an August 19-22, 1955, inspection, the report both listed conclusions and recommended further investigation. Among the more pressing needs were considered to be data on the potentials of the watershed, the pristine vegetation, effects of elk grazing on soil and vegetation, period of time elk occupy the summer range, numbers and distribution, relative amount of trampling, normal pocket gopher (*Thomomys talpoides tenellus Goldman*) population levels, a determination whether depleted range encourages large gopher populations, and the hydrologic and ecologic effects of pocket gophers.

Information obtained on the foregoing questions and other relevant data are presented in this paper. It is hoped the report will promote an improved understanding of Big Game Ridge and its elk population. Investigation was initiated in the summer of 1967 and continued through September 1971. Big Game Ridge was visited on 18 separate occasions during this period and 31 days were devoted to field studies. Studies were conducted almost entirely on that portion of the ridge in the Teton Wilderness area. This area and that within the National Park have never been grazed by domestic livestock.

It was apparent that background information was lacking and a significant portion of this report is an appraisal of historic and ecological material relevant to Big Game Ridge and adjacent ranges. These data were the result of an extensive search of various literature sources.



Figure 1. Simulated high altitude view showing relationship of Big Game Ridge to other mountains, basins and plateaus.

## ACKNOWLEDGMENTS

In 1967 the author was assigned the responsibility of evaluating elk habitat relationships on Big Game Ridge. The work was accomplished coincident with other wildlife habitat jobs of the Wildlife Biologist. This study is the outgrowth of this assignment which has been a stimulating challenge in ecological interpretations.

The author is indebted to D. M. Gaufin, Assistant Regional Forester, Region 4, who conceived the study and made the initial assignment. Complete latitude was afforded in placing emphasis where deemed necessary.

The author is most appreciative for the help and encouragement of Glen Cole and Douglas Houston of Yellowstone National Park. Special thanks is due Dr. Houston for his critical review and helpful suggestions on editorial changes in the manuscript.

James Yorgason, Biologist with the Wyoming Game & Fish Commission, was most helpful throughout the study. Many hours were spent in his company and his experience and data were liberally drawn from in making interpretations.

Monte E. Lewis identified plant specimens and his assistance is gratefully acknowledged.

Thanks is also extended to Floyd Noel, Paul Shields, Bill Wertz, Charles Knight, Tom Phillips, and Edward Slatterer, all of the Forest Service and Lloyd Loope of the National Park Service for critical and constructive reviews of the manuscript.

# METHODS

The author observed Big Game Ridge once from the air and three times on the ground during the summer of 1967 in the company of both Forest Service personnel and those in other agencies. This allowed an opportunity to make a reconnaissance of the area while in the presence of those with varying opinions.

In order to provide quantitative data, a permanent base line transect was established in vegetation at about the 9,600 foot contour in the middle fork of Wolverine Creek on August 7 and 8, 1968 (Fig. 2). The transect was comprised of 18 - 3' x 3' permanent photo plots (hereafter called quadrats) spaced at irregular intervals over about one mile distance. Quadrat locations were principally selected to sample sites having low densities of vegetation and which had previously been believed to be in depleted condition. Quadrat corners were permanently marked with angle iron stakes at diagonal corners. The camera point was located with a half-inch rebar rod. Close-up and panoramic photos were taken immediately following installation. Thereafter, panoramic scenes were made yearly (Figs. 3 and 4). Concurrent with the taking of initial photographs, vegetation occurring within each quadrat were listed for future comparison. Data on phenology, elk use of vegetation, elk tracking on soils and gopher disturbance were recorded in quadrats at recurrent intervals through the summer and fall from 1969 - 1971. These data provided an opportunity to assess biotic influences and the timing of these influences on the soil and vegetation.

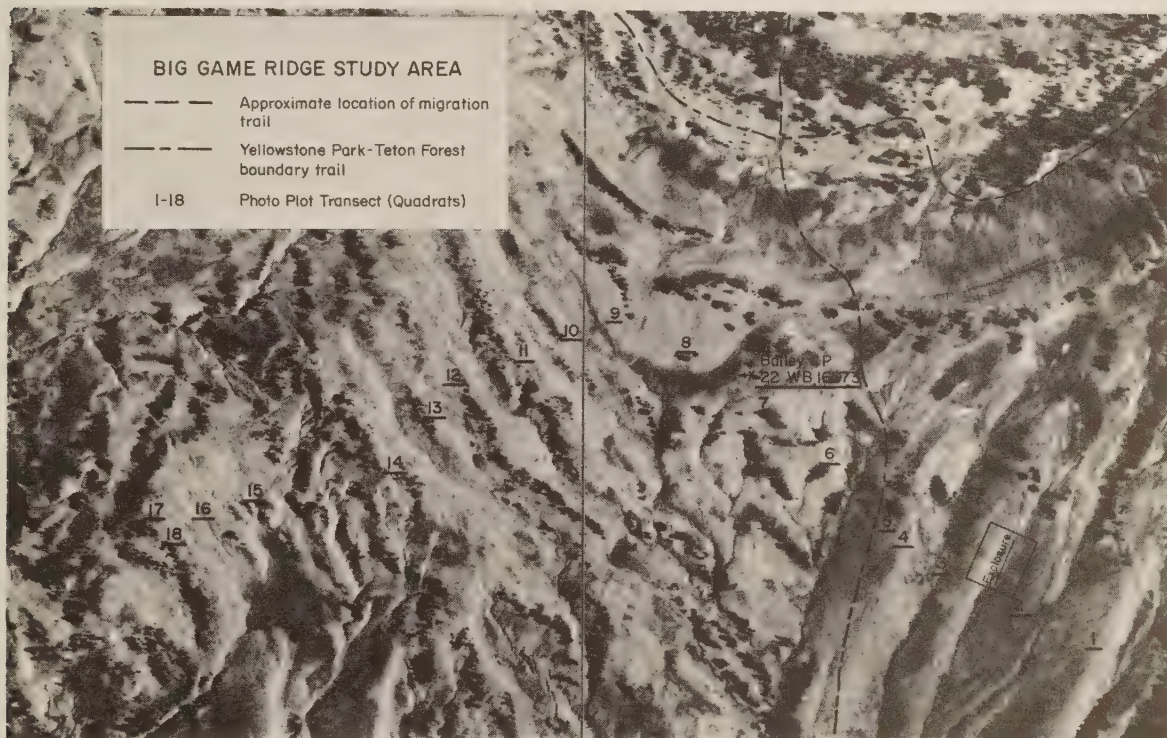


Figure 2. Location of quadrats 1-18 in relationship to Big Game Ridge enclosure.



**Figure 3.** August 7, 1968. Elevation 9600'. Quadrat 8 showing method of installation. Typical site of low vegetative potential. Note both fresh and old gopher mounds.



**Figure 4.** Line of transect from quadrat 8 to quadrat 9. Exposure is southerly. Soils are shallow with high gravel and cobble content.

The relative abundance of elk was measured by means of 40 - 1/100 acre pellet plots paralleling the photo transect at two chain intervals. Additional information on soil disturbance by gophers in early fall was provided by mound counts within these plots. Winter gopher casts were also recorded in this manner in the spring of 1970. Forage utilization by volume estimate was made in quadrats. Volume estimates were also made in a .96 square foot circular hoop placed in the center of the 1/100 acre plots. These estimates were made concurrently with fall pellet counts in 1969 and 1970.

Rephotographing six photos taken in 1915 and 1928 provided an objective means of evaluating range condition and trend on Big Game Ridge. Four other early high elevation scenes have been included in this publication in order to show trends on similar high elevation forb types.

Soils samples were analyzed by laboratory and field examination by qualified personnel from the University of Idaho and the Intermountain Regional Office of the Forest Service. Soil pits were dug on sites representative of contrasting conditions of vegetation to sample major soil types. The vegetative composition was determined by collection during the course of two summers.

Past fire occurrence was investigated from ring count of sections removed from fire-scarred trees and by increment cores taken from trees established since the most recent fire.

Elk movements and distribution were recorded during the course of 31 days in the field and during June flights over the study area.

# THE STUDY AREA

## Name Origin

Big Game Ridge was known as "Elk Ridge" on the 1859 Raynolds map (Raynolds, 1867) and on the 1873 Jones map (Jones, 1875). In 1885 the name was changed to Big Game Ridge on the U. S. Geological Survey Lake Quadrangle of that year.

## History of Exploration and Research

The Sheepeater Indians, a branch of the Shoshonean family, are the only known tribe to have been permanent residents of adjacent Yellowstone Park. It seems likely that these people hunted the Big Game Ridge locality prior to the arrival of Euro-American man.

The Big Game Ridge region was first frequented by whites during the fur trapping era. With the exception of Osborne Russell, the trappers did not leave a written account of their observations (Haines, 1955). Captain Barlow (1872) was the first white man to record observations on Big Game Ridge. His report, although lacking in detail, gives some insight on conditions at this time. In a hasty reconnaissance, Barlow named Mt. Sheridan and Mt. Hancock.

Bradley (1873), while conducting geological studies with the Hayden Survey, also recorded observations in the Big Game Ridge locality, apparently crossing the ridge somewhere near Mt. Hancock. A year later an engineering reconnaissance, under the direction of Captain W. A. Jones, circumvented Big Game Ridge by following a route around the south shore of Yellowstone Lake (Jones, 1875).

During late October and early November 1876, Lieutenant G. C. Doane described conditions between Yellowstone Lake and the Snake River Gorge (Doane, 1877).

Between 1884 and 1904, Government surveys continued with emphasis on geological studies. The geological project leader, Arnold Hague, an astute student of wildlife, made numerous observations during this period (Hague, 1893).

In the early 1880's, big game hunters, learning of the numerous elk south of Yellowstone Lake, began frequenting this area. The foremost of these hunters was Theodore Roosevelt who hunted the Two Ocean Plateau - Big Game Ridge area in 1891 (Roosevelt, 1893).

In 1891, the area south of Yellowstone Park, including Big Game Ridge, was placed in the Yellowstone Timber Preserve. The forest conditions in the preserve were examined in the summer of 1897 by T. S. Brandegee, the well-known botanist (Brandegee, 1899). This preserve was abolished in 1908 and the area placed under the administration of the Forest Service.

Elk hunting on Big Game Ridge and adjacent country was suspended from 1905 - 1935 with creation of the Teton State Game Preserve. Conditions during the era have been reported upon by Bailey (1915), Bailey and Simpson (1915), Rosencrans (1915), Bailey (1926), and Murie (1934).

Concern over the condition of the Big Game Ridge watershed developed in the late 1940's. Repeated inspection trips were made to Big Game Ridge by Forest Service personnel and cooperators through the 1950's. Conclusions based upon these reconnaissance trips are reported by Wogensen (1951), Beetle (1952), Deinema (1954), Anderson (1958), and Croft and Ellison (1960).

Forest Service habitat studies were not initiated until the summer of 1952 at which time two Parker 3-Step condition and trend clusters (Parker, 1951) of four transects were established. A third Parker 3-Step cluster of two transects was installed in 1957. Those established in 1952 were remeasured in 1958. All transects were again remeasured in 1966. Genz (1968) found that these data were usable for measurement of plant density and species composition, but found it to be unusable for determining trend.

The vegetation on Big Game Ridge was condition-typed by Casebeer and Wogensen (1958) using standard Region 4 range analysis procedures. From this survey, it was concluded that 12,786 of

15,451 acres were in a "poor" or "very poor" condition class. Basis for these classifications was a soil cover inadequate to properly protect the watershed.

Investigations were intensified in 1960 with construction of the 3 acre Big Game Ridge exclosure which excluded elk. Five permanent .96 square foot plot transects of 10 plots each were established inside and outside this exclosure in September, 1960. Photos were taken in 1960 and repeated in 1962 and 1966. Estimates of percent vegetation and litter, rock and pavement, and bare ground were initially made in 1960, and again in 1962 and 1966.

A second elk exclosure, one acre in size, was constructed on Gravel Creek in August 1962. An earlier attempt to maintain a 4 acre exclosure was unsuccessful. Three .96 square foot plot transects were established inside and outside this exclosure. These transects were also remeasured in 1966 and suggested no apparent trend.

Wyoming Game & Fish elk habitat studies have recorded elk occurrence and evaluated utilization of forage by elk. Since 1960, forage use transects and pellet transects have been run annually on Big Game Ridge.

Elk habitat investigations have also been carried out on the adjacent southern Yellowstone National Park summer range. These studies began in 1960 with construction of exclosures and installation of Parker 3-Step transects. The area was studied intensively between 1963 and 1968, after which the study was put on a maintenance basis (Cole, 1969).

# THE ELK POPULATION

It seems probable that a close ancestor to the Rocky Mountain elk arrived in Central North America between 35,000 and 25,000 years ago. The present modern species probably moved from and back into regions that became Grand Teton and Yellowstone Parks with the advance and retreat of less extensive intermountain glaciers, which reached their maximum 12,000 to 10,000 years ago (Cole, 1969).

Many writers have considered that elk were formerly plains animals which were pushed to the mountains by settlement (Skinner, 1927; Rush, 1932 and others). The basis for this idea was largely early reports which suggested game was abundant on the plains and scarce in the mountains. Murie (1940) showed this reasoning was illogical through a literature review and sound deduction which demonstrated that elk frequented the mountains of northwestern Wyoming in large numbers prior to settlement of the state. Murie's earliest references were those of Osborne Russell who reported elk numerous on the north shore of Yellowstone Lake in August, 1836 and the "whole country" east of Yellowstone Lake "swarming with elk" in August, 1837.

The failure to mention sightings of elk in early reports was not in itself positive evidence that they were not plentiful in the mountains (Murie, 1940). It is understandable that game was more easily observed in the open plains and comparisons were made with the mountains on this basis. Routes of travel in the mountains were invariably through valleys where elk were scarce during the summer having moved to the higher elevations to escape molesting insects. Then too, elk were easily disturbed well in advance of the party which accounted for lack of sightings as described by Lieutenant Jones (1875). Indian hunting parties were also responsible for a scarcity of elk in some instances as experienced by Theodore Roosevelt. Arnold Hague (1893) found them scarce at other times for no apparent reason. More recent studies (Cole 1969), show considerable variability in annual and seasonal use of high elevation summer ranges by elk.

Further search of the literature during this investigation has brought to light information that leaves little doubt that elk were also numerous on Big Game Ridge prior to the settlement of Wyoming (Appendix I).

A suggestion that Big Game Ridge was a summer range for many elk during the trapping era is noted by its original name "Elk Ridge" on the Reynolds map of 1859. The information source for the Yellowstone region was Jim Bridger, Captain Reynold's guide, who frequented the region yearly from about 1822 - 1843.

The observations of Captain Jones (Appendix I) suggest the elk population adjacent to Yellowstone Lake was much the same in 1873 as it was 36 years earlier during the time of Osborne Russell. It is reasonable to assume that a similar situation existed on Big Game Ridge. In 1871 and 1872, both Lieutenant Barlow and Frank Bradley, the geologist, followed game trails on the slopes of Big Game Ridge. Barlow does not mention elk, but comments that signs of game abounded on adjacent Two Ocean Plateau. Bradley saw 20 elk in two different groups and his comment of numerous trails would indicate that elk inhabited the area in considerable numbers, but had either been pushed into cover or were dispersed, as is often the case in September (Anderson, 1958).

References to "numerous" or "well worn" trails appear in the literature quite consistently. The condition and number of trails are added positive evidence that elk had been summer residents of the mountain areas for centuries, if not millenia.

The historical importance of the Big Game Ridge region as a summer elk range was best expressed by Hague (1893). He considered that "the headwaters of the Snake River furnish one of the best breeding grounds for elk anywhere to be found". In an earlier report (Hayden, 1885), Hague observed that the lands south and east of the Park were "natural haunts of elk and deer and which are regarded as amongst the best game regions in the Rocky Mountains".

An estimate of 5,000 elk on Big Game Ridge and Two Ocean Plateau in 1915 suggests they were frequenting the study area in large numbers (Rosenkrans, 1915). Four to five hundred were observed in the general area of the present study in August, 1915 (Bailey, 1915). Numbers appear to have been high in 1934 since there was concern over a slaughter if the area was opened to hunting (Murie, 1934).

Ground trend counts along a transect from Gravel Peak to Mt. Hancock were carried out four times during the period July 29 - August 21, 1956 and 1957 by Wyoming Game & Fish personnel. Numbers counted varied from 213 to 389 with the higher counts in or near Yellowstone Park (Anderson, 1958). During the current investigation, 200 - 300 were observed in the study area on several occasions. The highest count ran approximately 400 animals (Table 1).

Table 1.—Elk observations on Big Game Ridge 1915 - 1971.

Date	No. Elk	Locality	Source
Aug. 19, 1915	400 - 500	Study Area	Bailey, 1915
July 29 - Aug. 4, 1956	346	T. Forest-Y. Park	Anderson, 1958
Aug. 15 - 21, 1956	389	" "	" "
July 29 - Aug. 4, 1957	268	" "	" "
Aug. 15 - 21, 1957	213	" "	" "
July 30, 1964	199	Study Area	Yorgason (Pers. comm.)
July 23, 1965*	147	" "	" "
July 29, 1966*	138	" "	" "
July 11, 1967	171	" "	" "
July 28, 1967*	296	" "	" "
Aug. 15, 1967	250 - 300	" "	" "
July 15, 1968	100	" "	" "
July 30, 1968*	127	" "	" "
Aug. 6 - 8, 1968	38	" "	Gruell (this study)
Aug. 12 - 13, 1969	175 - 225	" "	" "
July 16, 1970	350 - 400	" "	" "
Aug. 4, 1970	380 - 400	" "	" "
July 14, 1971	170	" "	" "
Aug. 19, 1971	61	" "	" "

\*Aerial observation

It is reasonably certain that the elk population on both Big Game Ridge and adjacent summer ranges was near historic levels through the mid-1890's. Up to this time there had been little promiscuous killing of the southern elk herd and livestock grazing on the winter range was of little consequence. The winter range for these animals since pristine times had principally been the Jackson Hole Valley and the Buffalo and Gros Ventre tributaries to the Snake River (Cole, 1969). The primary area of use in the valley included the present National Elk Refuge, north of Jackson; the Gros Ventre Buttes to the west and bottom lands south of Jackson. Large numbers moved yearly into this region, as reported by Hough (1887) and recounted by Anderson (1949) and Hedrick (1952). Later tagging studies on the National Elk Refuge and migration studies have demonstrated that the majority of these animals continued to follow traditional patterns by migrating to Big Game Ridge and Yellowstone Park summer ranges (Anderson, 1958).

During historic times the summer population fluctuated in numbers as a result of wide variations in winter severity. The winters of 1886-87 (Allred, 1950) and 1889-90 (VanDeveer, 1939) were particularly severe.

A steady decline in the elk population may have begun with heavy losses during the severe winter of 1896-97 (Barnes, 1912; Bailey and Simpson, 1915), a sharp increase in promiscuous killing of elk during the ensuing years (Macrum, 1902), and with the accumulative loss of the more important valley winter range to ranching (Miller, 1909; Preble, 1911 and Gunther, 1912). Losses appear to have accelerated during the period 1900 - 1911, being particularly influenced by the consecutive hard winters of 1908-09, 1909-10, and 1910-11.

A winter feeding program was initiated in 1912 on the newly established National Elk Refuge to help compensate for losses of winter range to ranching. There appeared to be no alternative if the herd was to be maintained (Miller, 1909 and Gunther, 1912). In subsequent years the Wyoming Game & Fish Commission was compelled to enter into feeding programs in other localities to alleviate damage to ranchers' hay and minimize losses of elk to malnutrition.

The first comprehensive census of the Jackson Hole herd took place during the winter of 1916 with a count of 19,763 elk. Periodic counts since 1916 suggest a 30% reduction in the herd size (Cole, 1969). When counting methods and animal distribution are taken into consideration, this reduction appears to be conservative. Early ground counts almost certainly underestimated the size of free-ranging herds. Counting accuracy improved in later years as the greater majority of the wintering herd was on feedgrounds and free-ranging animals were counted by air. Recent counts suggest 15,000 - 20,000 elk wintering in the Jackson Hole area (Yorgason, per. comm.).

This historical review puts a different perspective on the relationship between the Jackson Hole wintering herd and the Big Game Ridge summer population. Many previous workers had considered that elk were not indigenous to the mountains or that winter feeding had increased the summer herd beyond former levels and brought about a deterioration of the summer range from overgrazing. An indicated reduction in the Jackson Hole herd in excess of 30% since the late 1890's does not support this premise.

# THE PHYSICAL ENVIRONMENT

## Physiography

Big Game Ridge is a narrow mountain uplift about 15 miles in length, located in T.48N., R.112W., and 113W. and in T.47N., R.112W. The larger portion of this ridge (34,237 acres) is in the Teton Wilderness with the northern third (19,565 acres) projecting into Yellowstone National Park. All the elevated country between Gravel Creek on the south and the Snake River Gorge on the north is included in this land feature.

Big Game Ridge follows a course slightly west of north to Mt. Hancock, from which point the direction changes to northwest. Elevations vary from 8,900 feet at Fox Creek - Wolverine divide to 10,150 feet at Mt. Hancock. This ridge forms an important segment of the upper Snake River watershed. Although steep slopes occur, the prevailing topography is gentle rather than rugged, with broad ridges, moderate slopes, and alluvium-filled valleys. The upper slopes of Big Game Ridge are open and subalpine in aspect with patches of whitebark pine and subalpine fir. Most of the country lying below the open ridge is forested with whitebark pine and subalpine fir at higher elevations grading into lodgepole pine and subalpine fir at lower elevations.

The study area at the headwaters of the middle and west forks of Wolverine Creek (Fig. 5) is strongly dissected and has been considered the primary area of poor hydrologic condition on the Forest segment of Big Game Ridge. A series of deeply entrenched gullies is the predominate land feature. The non-forested tall forb-type within this complex includes approximately 3,350 acres.

## Climate

Annual precipitation on Big Game Ridge, for the most part, is snow. Summer rain storms, some of high intensity, contribute to the total. Records for 5 years from Two Ocean Plateau, 10 airline miles to the east at about 10,000 foot elevation suggest the annual precipitation (snow and rain) on Big Game Ridge approaches 50 inches. The U. S. Soil Conservation Service Summary of Snow Depth Measurements (1967) for northwestern Wyoming shows an average of 107 inches at Lewis Lake (7,900'). Average water content for the same period was 44 inches.

Snow depths in the study area often exceed 100 inches in draws and on ridge crests facing north and northwest. Depths are quite variable and are generally less on west and southwest exposures. Drifts are largely melted by the last week in July, although some persist throughout the summer in given years. First snowfall, which usually remains throughout the winter, occurs in mid-September.

The climate in Jackson (6,244') is classified as a cold, snowy forest-type with humid summers. Temperatures show a wide range between summer and winter and between daily maximums and minimums. Summers are short and cool - winters long and cold with lasting snows. Nighttime frosts on Big Game Ridge occur periodically in July and August.

Weather records covering the period 1931 - 1960 from the Pacific Northwest River Basins Commission (1969a; 1969b) show an annual mean temperature of 34.7° F. for Moran (6,800'). January, the coldest month averaged 10.6° F.; July with an average of 57.9° F. was the warmest. Using a lapse rate of 4.4° F. per thousand feet elevation developed by Potter (1969) for western Wyoming, the annual mean for Big Game Ridge would be about 21° F. January's mean would be below 0° F. and July's about 45° F. In short, Big Game Ridge is distinguished by having an extremely harsh climate and a very short growing season.

## Geology

Love (1956) discussed the geology of the Big Game Ridge locality in some detail and the following is summarized from this publication and a personal communication (1971).

Geologically, Big Game Ridge is formed of the Harebell formation. This formation is composed of a thick succession of olive-drab to gray sandstone, conglomerate, tuff, claystone, and shale of late Cretaceous age overlying older Cretaceous rock with a slight regional unconformity. It is also overlain by Paleocene and younger Tertiary rocks with a major angular discordance.

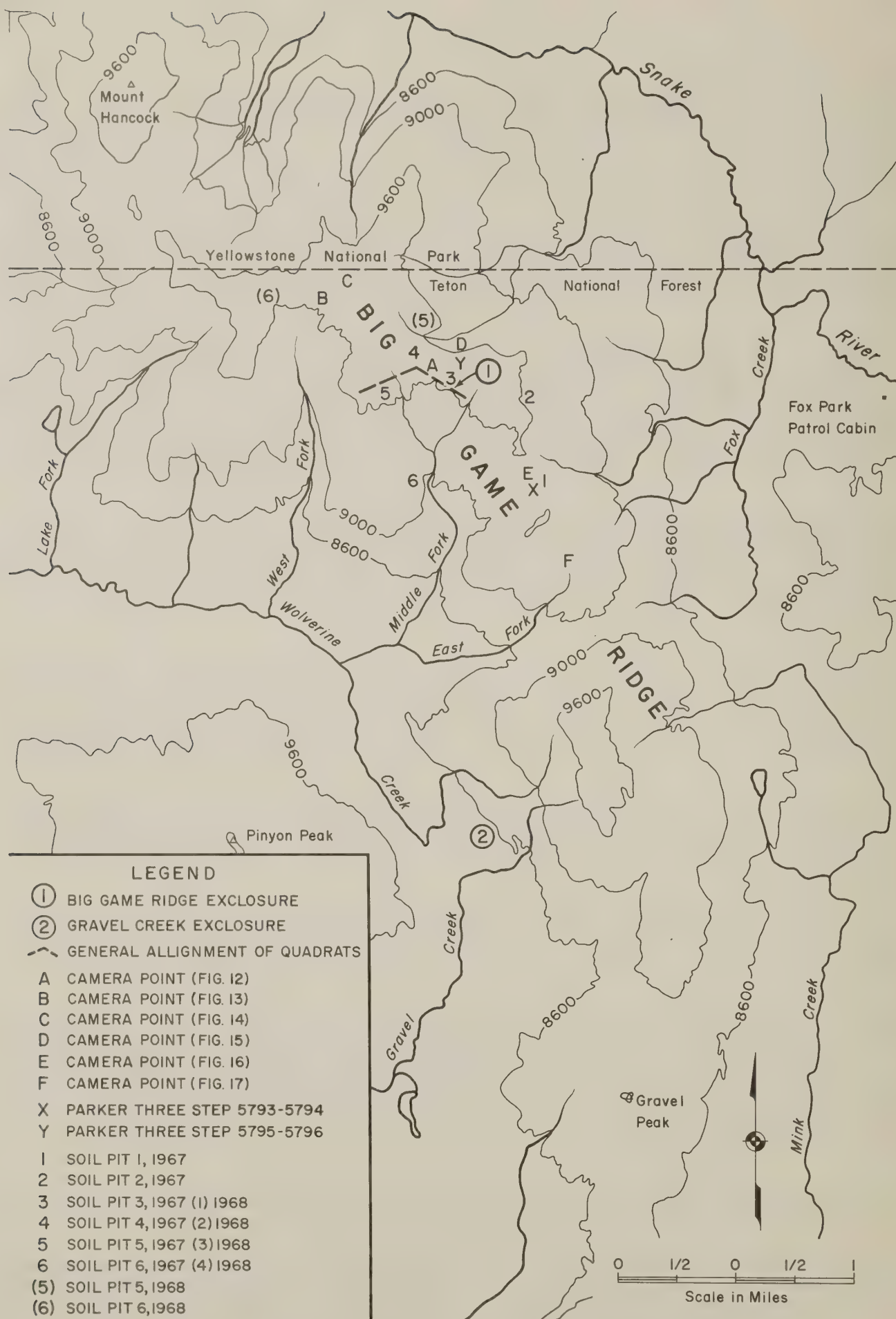


Figure 5. Big Game Ridge study area showing location of sites where sampling took place.

The formation has been gently folded into several anticlines and synclines and on the south side of Big Game Ridge landslides complicate the section. Because of unconformities at both the base and the top, the formation has considerable variation in thickness. In the type area, the thickness is about 10,000 feet. The sediments that form the Harebell formation were largely laid down in and adjacent to a shallow sea that advanced across Wyoming from the east and then retreated eastward for the final time at the end of Harebell deposition.

The occurrence of numerous fossil leaves and invertebrates indicate a hot, wet climate during late Cretaceous time. The landscape had low relief, but powerful rivers flowed eastward across it from mountains to the west and on into the sea to the east.

Big Game Ridge, although originally folded and uplifted more than 60 million years ago, was carved by ice during Pleistocene time. This phenomenon had the greatest influence on the landscape as we know it today. The following summary by G. M. Richmond (1972, pers. comm.), based on previous field studies (Richmond and Pierce, 1971) provides a new perspective on the development of the slopes and surface deposits of the Big Game Ridge study area.

All of the erosion and uplift in the canyon of Wolverine Creek took place before the last two major Pleistocene glaciations, the earlier of which began about 120,000 years ago. Since then, the major elements of the topography have remained essentially the same.

Glacial erosion during the last two glaciations smoothed and streamlined summit areas and other ridge crests in the direction of ice movement. The ice also stripped away all pre-existing soil. During the earlier glaciation, called the Bull Lake Glaciation, Big Game Ridge was entirely covered by ice. During the last, or Pinedale Glaciation, its upper 200 feet projected above the ice. However, neither glaciation resulted in any significant deepening or widening of the valleys of Wolverine Creek and its tributaries. The ice merely filled and overflowed them in the course of its overall southwesterly advance, and deposited from less than 5 to more than 30 feet of stony, sand-silt till on their slopes.

It was during the closing phases of the Pinedale Glaciation that the detailed topographic features of the study area were formed. The ice, which had been over 2,000 feet thick in the valley of Wolverine Creek, melted completely in less than 1,500 years. Vast amounts of meltwater flowed from an ice surface that was being lowered at the rate of more than 100 feet per year. The sand and gravel carried in this water was mostly transported far downstream, but some was deposited along the lower valley of Wolverine Creek. These deposits are only a few tens of feet thick, which suggests that the ice had very little rock debris in it.

Valley slopes which were exposed as the ice downwasted were fully saturated, and these slopes thawed and froze diurnally during the summer season. Under prevailing conditions, flowage of glacial deposits from the upper slopes to the lower slopes was widespread, being greatest on south and southwest-facing slopes. The southwest-facing slope of Big Game Ridge was essentially stripped of glacial deposits by these processes and the upper reaches of Wolverine Creek and its tributaries were gullied several tens of feet by mud flows and by heavily loaded streams transporting debris from the slopes to the main valley. Today only a thin veneer of glacial rubble remains on the bedrock slopes. South of the main valley of Wolverine Creek, the north-facing slopes tended to remain frozen and to thaw gradually, flowage was not on a large scale and, as a result, the upper slopes are still largely covered by glacial deposits.

Following disappearance of the ice, the slopes stabilized rapidly and vegetation developed. The following summary of its development is after Baker (1970) and Waddington and Wright (1970). From about 12,500 years ago to about 11,800 years ago the vegetation was a tundra parkland, similar to that near tree line at high altitudes today. The forest areas were predominately of *Pinus albicaulis*, *Picea*, *Juniperus*, *Salix*, *Betula* and *Populus*; the tundra mainly of *Artemisia* and *Gramineae*. About 11,800 years ago the forest was principally of *Pinus contorta* and *P. albicaulis*, which suggests cooler and especially drier conditions than the present. About 9,500 years ago it became chiefly *P. contorta*. This change marks the beginning of the Altithermal interval, which was warmer and drier than the present. About 6,000 years ago the present forest of *P. contorta*, *Picea* and local *Abies* developed as the climate cooled during the so-called Little Ice Age or Neoglaciation.

During the Altithermal interval, gullying to depths of 10 - 30 feet took place along small streams on

the upper slopes of Big Game Ridge and stream terraces 15 - 30 feet high were cut in gravel deposits originally deposited during the glacial recession along the lower valley of Wolverine Creek.

During Neoglaciation, frost action on summit rock areas and talus fall below cliffs was renewed on a small scale and soil flowage at the base of slopes caused lobes of material 3 - 4 feet high to flow out over the surface of gravel terraces in the main valley. However, upland slopes remained mostly stable and with more favorable soil moisture conditions than existed during the Altithermal. The cooler episodes were separated by warmer times not unlike those of today. Neither the cool episodes nor the warmer episodes caused any large scale change in the dominant vegetation outside the cirques; at least, no change is recorded in the pollen spectra of peat bogs from which the vegetation history has been derived. At present, slope erosion is very minor and restricted to times of spring runoff and occasional torrential summer rains. There is probably less erosion at present than during the dry years of the 1930's though no record of erosion in the area at that time is available.

## Soils

Sampling of soils in 1967 and 1968 has provided information from which a partial, though meaningful assessment can be made of the soils - vegetation relationship.

The 1967 samples were taken from six sites where production of vegetation varied from poor-to-excellent (Fig. 5). Laboratory analysis suggested that plant nutrients are essentially adequate for the variety of native plants growing on Big Game Ridge (Table 2). In 1968, soils were resampled and described on four of the six sites. Two new sites were also sampled (Fig. 5); (Appendix III). Field measurements showed soil pH to be considerably higher than 1967 laboratory analysis. This difference could be due to real changes, but is more likely related to a difference in sampling techniques (Wertz, 1970).

Table 2.—Characteristics of 1967 soil samples collected on Big Game Ridge.

Location	pH	P (lb/acre)	K (lb/acre)	NA (Meq/100g) <sup>1</sup>	Total Salts (mmhos) <sup>2</sup>	Soil Organic Matter (%)
Stop 1	4.70	7	307	.049	0.25	1.88
Stop 2	5.20	13	166	.049	0.30	1.14
Stop 3	4.90	6	170	.049	0.30	3.96
Stop 4	5.30	16	254	.049	0.25	4.13
Stop 5	5.20	10	307	.146	0.32	3.07
Stop 6	5.10	4	410	.499	0.70	3.81

<sup>1</sup>A measure in milliequivalents of the amount of sodium held in the soil available for plant growth.

<sup>2</sup>Measure of excess soluble salts in the soil. Determined by measurement of electrical conductivity of the moist soil.

Diem and Kennington (1963) reported no elemental deficiencies from laboratory analysis of parent rock. Hot house samples of Big Game Ridge soil samples seeded to oats suggested production of vegetation was being suppressed by some factor other than soil fertility.

Soils sampled in 1968 (Appendix III) suggested there was a variety of soil conditions over the area including deep fine-textured glacial till soils; very shallow, sandy soils; moderately deep shaley soils; and fine-textured soils developed on slumps. The condition of vegetation that has developed on shallow, sandy soils has been of major concern. On the Forest, these soils are essentially confined to the ridgetop from the head of the west fork of Wolverine Creek east some one and one-half miles.

Production of vegetation on sites sampled in 1968 range from poor-to-excellent. The sites are considered to be representative of the variation in condition of the vegetation on Big Game Ridge.

Investigations suggested that the potential for formation of productive soils is present in the parent rock, since laboratory analysis showed no nutrient deficiencies or excess salts. In 1968, the soil pH in the top 18 inches of the soil surface ranged between 5.0 and 6.5. The more acid soils tended to be from shale parent material. Sandy soils tended to be less acidic. These data and the hot house experiments by Diem indicate the soils on Big Game Ridge have an inherently good potential for producing vegetation.

However, soil texture and moisture holding capability varies considerably. Soil pits showed sparsely vegetated sites are invariably underlain by shallow-cobbly soils and/or sandy materials. Growth potential is limited by a reduction in the effective rooting depth and rapid drying of the soil surface. The harsh microclimate of snowbank areas dictate poor vegetal cover. By contrast, the better producing sites are represented by rather deep loamy soils underlain by clay. These soils afford ample room for rooting while retaining moisture more efficiently.

### **Watershed Condition and Erosion**

Since the late 1940's, the condition of the Big Game Ridge watershed and accompanying erosion rates have been the primary subject of concern and discussion. It was commonly accepted that the hydrologic condition was poor and of rather recent origin. Conclusions were based upon a high incidence of erosion pavement sparse ground cover, pedestaled plants, gullying and deposition of debris in the lower drainages. It had been concluded that most of the topsoil had been eroded away resulting in a widespread prevalence of erosion pavement. The overall prevailing condition was likened to overgrazed and damaged livestock range in Montana, Idaho, Wyoming, Utah, Nevada and other western states (Croft and Ellison, 1960).

L. A. Stoddard speculated that the range had been in better condition in the past. How much better he did not speculate. Conclusions were based on dead plant segments, erosion pavement and lichen crusts (Deinema, 1954). Wertz (1970) concluded that much of the poor hydrologic condition was new in origin - probably less than 100 years. Reason for this view was expressed as follows: "If the present erosion forces and patterns had been active and developing for a longer period, the topography would be much different than presently exists." Diem and Kennington (1963) point out that the slow percolation rates for Big Game Ridge soils tested suggest how easily water runoff could reach proportions to cause serious soil erosion.

From the foregoing one can appreciate that watershed conditions on Big Game Ridge are "poor" when the usual criteria are applied and on certain sites the plant cover and soil makeup is inadequate to inhibit rapid runoff (Fig. 6). However, despite past interpretations, the question as to whether the erosion rate and watershed condition are natural geologic or an accelerated condition brought on by processes attributable to modern man has not been satisfactorily answered.

A valuable aid in evaluating current watershed conditions is an awareness of how these watersheds appeared in the past. Fortunately, two professionals described conditions in the 1870's.

Barlow (1872) writing of the condition of the Snake River in the Crooked Creek locale states, "The stream is one of the principal branches of Snake River, has a rapid current, and is subject to severe freshets." Bradley (1873) also comments on the wide variability of runoff by saying, "The mountains shut off the winds on all sides, and the valley lies so well to the sun that the snows must melt rapidly here, thus causing the great freshets of which the broad, gravelly bottom of the river below had already given so abundant evidence." Bradley also contrasted the stability of Heart River with other streams of the area where great freshets were common. On the prevalence of erosion, he made the following comment: "The upper slopes of the ridge on either side are mostly bare of timber and many parts of them are badly washed."

Though brief, these accounts demonstrate that the watershed in given localities during the 1870's was subjected to heavy runoff in the tributaries which was accompanied by deposition of debris in the lower drainages. The slopes, being of erosive sedimentary material, were also badly washed in many locations.



Figure 6. July 23, 1969. Elevation 9600'. Watershed at the head of the west fork of Wolverine Creek showing the dispersed and sparse characteristics of the vegetation. Note elk bedded in heavy herbaceous vegetation at lower left center.

Bailey's 1915 photographs provide what is perhaps the most objective means from which to measure watershed change on Big Game Ridge. A critical comparison of these photos with the current scene shows the watershed essentially unchanged at these locations. An appreciation of the slow rate of erosion on slopes of low-to-moderate gradient is realized upon comparison with current photos (Figs. 12 and 13).

#### Wildfire

Brandege (1899) reports that little of the southern part of the Yellowstone Park Forest Reserve had escaped fires prior to his investigation in 1897. Ellison and Croft (1960) noted the evidence of early burning throughout the Big Game Ridge region. A ring count of a small conifer suggested an extensive fire about 1885.

Figures 12 - 15 in the middle and west forks of Wolverine Creek on Big Game Ridge show the conifer cover to have been predominately in an early successional stage in 1915. Increment samples from 13 whitebark pine suggest establishment about 1885 with successful regeneration continuing through about 1930.

To better ascertain the fire sequence in the study area, wedge-shaped sections were cut from 9 fire scarred trees. Ring counts suggested that some localities at the upper elevations of Big Game Ridge burned sometime in the 1840's and again in the 1860's. These data further suggest a fire of more widespread occurrence took place in the middle 1880's. This probability is supported by the appearance of young conifers in the 1915 photographs. Had the region burned over with uniformity at an early time, it is reasonable to believe the reproduction would have been of greater size in 1915. Observations tempered with a knowledge of fire research findings, makes one appreciate that fires at high elevations are infrequent but inevitable owing to heavy fuel build-up. The timing of these fires probably coincides with maturing conifer forests and a high incidence of trees killed by the mountain pine beetle.

The influence of past fires on the herbaceous watershed cover is of major interest. From known behavioral characteristics of high elevation fires, it is reasonable to assume that past fires were of a spotting and crowning nature rather than a sweeping type through fine fuels (George Fry, 1971 pers. comm.). The possibility of a more or less continuous ground fire through the study area is unlikely owing to the sparsity of fine fuels, particularly on the sites in poor hydrologic condition. In localities where the herbaceous cover has been adequate to support ground fires, it is highly improbable the heat generated was of high enough intensity to be injurious to the root system.

These findings show that fire has been an important natural abiotic agent on Big Game Ridge and that the influence of past fires must be considered in interpretations. The vegetation has evolved under the influence of periodic fires just as have other biotic and abiotic influences been a factor in its development. The evidence suggests that fire, although important, has been of lesser effect on watershed conditions than have other abiotic influences because of infrequent and low intensity fires in the tall forb community.

# THE VEGETATION

## Composition

Vegetation on the area is primarily an "herbland" or tall forb community similar in most respects to those described by Cole (1969) and Ellison (1954). Seventy plant species were collected by the author during the summer of 1968 and 1969 (Appendix II). The collection was made entirely in the middle fork of the Wolverine Creek study area with exception of a few specimens from the Boundary Trail and the East Fork of Wolverine Creek. Fourteen of the plants identified were grasses, sedges or rush, one was a shrub and 55 were forbs. Forbs are by far the most conspicuous component of the vegetation.

Vegetal composition and density by site is highly variable, being a function of site potential. Snow-bank situations and sites of shallow drained soils produce less than 250 pounds air-dry weight per acre. (Fig. 4). The characteristic species on these sites include mountain dandelion, mountain sorrel, thickstem groundsel, lupines, skyline bluegrass and Bear River fleabane, in varying proportions.

On the opposite end of the spectrum, areas with well developed deep soils of high moisture holding capacity produce up to 2,600 pounds air-dry weight per acre (Casebeer and Wogensen, 1958). A wide variety of plants comprise the vegetation. Characteristic species are mountain brome, slender wheatgrass, tall larkspur, mountain bluebell, thickstem aster, western yarrow, mountain lupine, sticky geranium, fernleaf ligusticum, elephanthead pedicularis and fivenerve helianthella (Fig. 7).



Figure 7. July 23, 1969. Elevation 9600'. High producing tall forb type in west fork of Wolverine Creek.

Parker Three Step transects (Table 3) provided quantitative data on the percent plant density, frequency of occurrence and ground cover on two contrasting sites. One transect was located on a dry site while the other bisected an alpine meadow. Ocular measurements of bare soil, rock and pavement, and vegetation and litter were also made within .96 sq. ft. plots both inside and outside the Big Game Ridge Exclosure (Fig. 8). These data further demonstrate the variability of vegetative composition and density.

Table 3.—Plant density, frequency of occurrence and ground cover on Parker 3-step transects - Big Game Ridge.

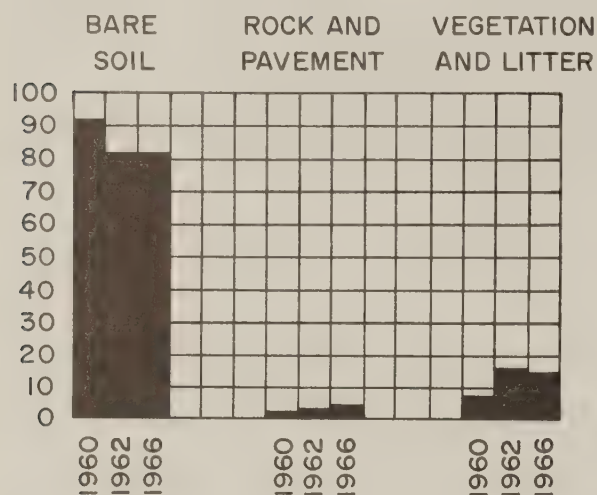
Plant Species	Percent Composition	
	Transect 5793 - 5794	Transect 5795 - 5796
Squirreltail		1
Bluegrass	12	7
Slender wheatgrass	6	
Sedge	2	12
Trisetum	2	5
Needlegrass	5	4
Hair-grass		12
Juncus		2
Grass Totals	27	Grass Totals 43
Cinquefoil	15	5
Mountain dandelion	10	7
Eriogonum	10	12
Western yarrow	30	6
Aster	6	15
Lupine	2	1
Strawberry		7
Pussytoes		3
Violet		1
Forb Totals	73	Forb Totals 57
Bare Soil	50	Bare Soil 41
Rock	6	Erosion Pavement 1
Litter	13	Litter 8
Plant Cover Index	30.5	Plant Cover Index 47

### Phenology

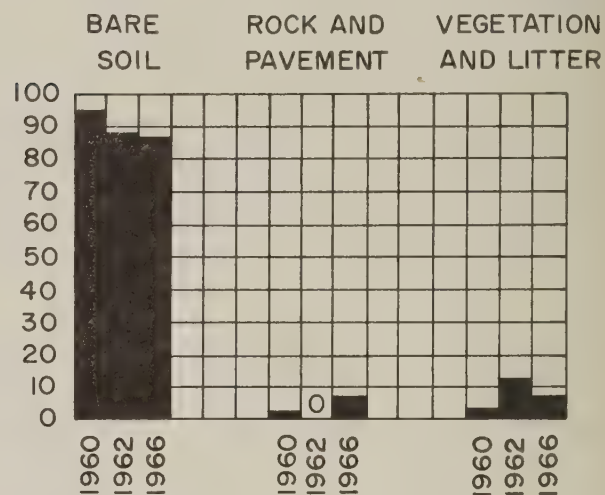
Plant emergency<sup>e</sup> was checked in late June 1968, 1969, 1971. A June 18, 1968, aerial survey showed the Wolverine drainage above Wolverine Meadows covered by a complete blanket of snow. Snow depths at the enclosure varied between 4 and 8 feet. Similar conditions were noted during aerial observations on June 25, 1971, (Fig. 9). Yorgason (1971 pers. comm.) reports on the basis of 11 years recurrent aerial observations that a nearly complete snow-cover is the rule rather than the exception during the third week of June.

Unusually early on-site observations were allowed at the Gravel Creek enclosure (9,200') on June 5 and at the 9,600' study area elevation on June 24, 1969. On June 24, 1969, the soil surface was essentially snow free except for large drifts on snowbank sites and in gullies (Fig. 10). Overall, the prevailing condition was one of early spring, as soils were fully saturated and surface runoff common.

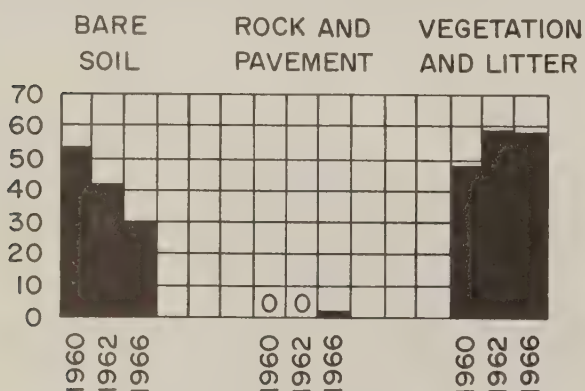
### TRANSECT NO.1 INSIDE EXCLOSURE



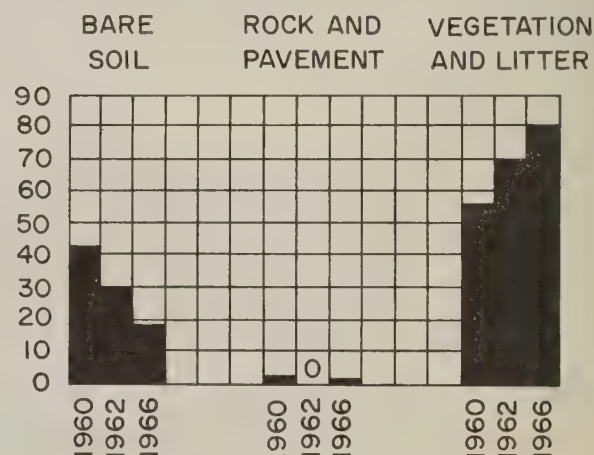
### TRANSECT NO.1 OUTSIDE EXCLOSURE



### TRANSECT NO.2 INSIDE EXCLOSURE



### TRANSECT NO.2 OUTSIDE EXCLOSURE



### TRANSECT NO.3 INSIDE EXCLOSURE

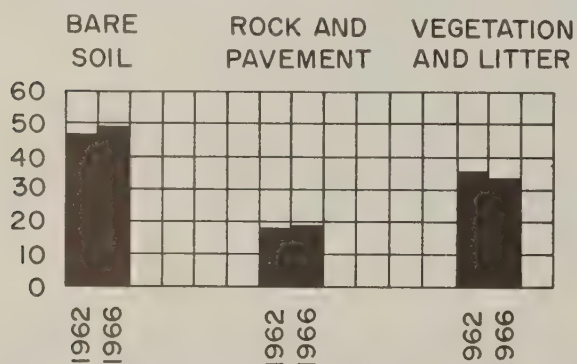


Figure 8. Variability of vegetation density and short term measurements on .96 sq. ft. plot transects inside and outside the Big Game Ridge exclosure. From I. R. Thornton, Range Conservationist, Teton National Forest.



Figure 9. Aerial view of Big Game Ridge study area on June 25, 1971, showing location of enclosure and snow conditions.

During the months of July and August, seven on-site inspections of the 18 quadrats allowed documentation of plant emergence and development. Quadrats had been placed on variable exposures, making it possible to record variations in development. Photos were also taken from permanent camera points to visually record growth characteristics.

Results from three years showed considerable variability between years and between sites. The years 1969 and 1971 may have been representative of climatic extremes. A normal snow pack went off rapidly in 1969, while a "near record" snowpack persisted in 1971. Growth started earlier than usual in 1969 and later than usual in 1971.

Wide differences in plant emergence and development by species on quadrats precluded presentation in tabular form. Growth characteristics by year are best illustrated photographically (Fig. 11). On July 8-9, 1969, grasses were in boot and forbs in flower stages of growth on early developing sites. Peak development for the study area was judged to be one to two weeks off on July 23, 1969. The 1970 growing season got off to a slower start than the year previous as suggested by July 16, 1970 data, while in 1971 growth lagged behind the previous two years with four quadrats under snow and four snowfree only a few days on July 14.

Despite significant differences in emergence and initial development, the vegetation as a whole reaches full development by the first week in August. By this time, temperatures are warm enough to influence rapid growth. Inspections of August 12-13, 1969, August 4, 1970, and August 19, 1971, all showed the vegetation at or past peak development.

Records over three years demonstrate extreme variability - as much as three weeks difference in onset of growth among years and four weeks difference between the onset of growth of vegetation on contrasting exposures.

#### Plant Succession

**Long Term Trends**—Previous investigators have questioned whether the current vegetal regime on sparsely vegetated sites is representative of the "original" vegetation. Croft and Ellison (1960) concluded that residual - resistant tufts of ovalhead sedge could well be the only component of the orig-

inal vegetation left as a result of excessively heavy elk use. From experience on the Wasatch Plateau in Utah, it was further theorized that lush vegetation on a southwest slope of Big Game Ridge, could represent the cover that once grew on the open upland parklands.

Beetle (1952) considered that the vegetation fell in the poorest condition class as a result of overgrazing by elk. Indicators of poor condition were considered to be a disparity between the heterogeneous pattern of cover on sparsely vegetated sites in contrast to a uniform pattern which typifies excellent sites; the large number of species represented on sparsely vegetated sites as opposed to a smaller number typical of undisturbed sites; the presence of too many "invaders" and "increasers"; general reduction in importance of "decreasers" and the uniformly poor ground cover. Other evidence of deterioration were the "evidently accelerated erosion and well developed erosion pavement".

Results obtained during the past four years suggest different interpretations.

Historic photos of vegetation on Big Game Ridge suggest no material change in composition and if anything, show an increase in plant cover during the past 56 years. These and other photos of high elevation sites show exceedingly slow plant succession on subalpine tall forb ranges or no change (Figures 12-21).

A reliance on pedestaled sedge plants as an indicator of range conditions can be misleading as demonstrated by Figure 20 on the Continental Divide (10,100'). The 1893 photo shows that pedestaled sedge plants are not necessarily a departure from natural events. Upon inspection of the site without benefit of the original photo, one could conclude that deterioration of the vegetation had occurred owing to pedestaling and dispersion of the principal sedge cover. The trend, however, is the opposite - as a significant number of these sedge plants have become established during the past 80 years.

Strong evidence that a dispersed plant cover is not necessarily a departure from natural events is further illustrated in Figures 18 and 21. Figure 18 (9,100') on an elk summer range, shows patterns of low density vegetation essentially the same as in 1928. A high occurrence of pocket gophers contributes to this condition. This locality has never been grazed by domestic livestock. Figure 21 (9,200') had a dispersed vegetative cover 100 years ago and this pattern still persists. The vegetation is influenced by shallow soils with high occurrence of rock and cobble. This area currently has low populations of native ungulates and is not grazed by domestic livestock.

My interpretations of these photos is that the tall forb community is essentially a climax vegetation. Naturally occurring local "zootic climax" sites result from recurrent use by elk. Changes in the vegetation shown in historic and recent photos appear to be related to variations in growing seasons, the influence of the pocket gopher and/or possible climatic changes.



Figure 10. June 24, 1969. Vegetational development and snow conditions at Big Game Ridge enclosure.



July 8, 1969



July 16, 1970



July 14, 1971

Figure 11. Vegetational development at Big Game Ridge exclosure. On comparative dates, 1970 was behind 1969; 1971 lagged behind previous two years. Note high occurrence of gopher casts in 1971.



Figure 12. Fish and Wildlife Service photo #22-WB-16073, by V. Bailey. August 19, 1915. Elevation 9600'. Ecotone between hermland on left and subalpine meadow on right foreground. Steep bare slopes are snowbank areas. Camera point is immediately adjacent to quadrat 7.



August 13, 1969. Conifers show conspicuous growth. Herbland vegetation appears more dense. No significant change in erosion patterns can be detected.



Figure 13. Fish and Wildlife Service photo #22-WB-B-16070 by V. Bailey. August 19, 1915. Elevation 9600'. Westerly view of herbland vegetation and slope dissected by numerous deeply eroded draws at head of west fork of Wolverine Creek.



August 19, 1971. Camera point is somewhat lower than original. The same trend prevails as in Figure 12. Note particularly, the apparent increase of vegetation on snowbank in foreground.



Figure 14. Fish and Wildlife Service photo #22-WB-16077 by V. Bailey. August 19, 1915. Elevation 9800'. Looking northwest from uppermost slopes of Big Game Ridge. Chicken Ridge in distance at right and Heart Lake on left. Darker vegetation is tall forb and mesic sites.



August 13, 1969. Poor quality of original photo makes interpretation arbitrary. Vegetational patterns are essentially unchanged. An improvement in ground cover is suggested.



Figure 15. Fish and Wildlife Service photo #22-WB-16072 by V. Bailey. August 19, 1915. Elevation 9400'. On Boundary Trail near game trail cutoff to Big Game Ridge enclosure. Slope faces northeast. Vegetation is tall forb association.



August 13, 1969. As in Figure 12, retake suggests an improvement in ground cover.



Figure 16. Fish and Wildlife Service photo #22-WB-34023 by O. Murie. September 2, 1928. Elevation 9400'. Herbland vegetation on Big Game Ridge, one mile southeast of Big Game Ridge exclosure.



September 16, 1969. The herbland vegetation shows no detectable changes. Note that there has been no appreciable change in gully headcutting in foreground.



**Figure 17.** Fish and Wildlife Service photo #22-WB-34073 by O. Murie. September 21, 1928. Elevation 9500'. Ridgetop site about two miles southeast of Big Game Ridge enclosure. Bared soil in foreground is pocket gopher diggings.



September 16, 1969. Change in perennial grass - forb association in foreground may be related to a difference in camera angles. Except for increased conifer growth, no appreciable change in vegetation is suggested.



Figure 18. Fish and Wildlife Service photo #22-WB-34048 by O. Murie. August 2, 1928. Elevation 9100'. Historic elk summer range on tall forb vegetation at head of Pilgrim Creek near Wildcat Peak. Note interspersed heavy and light vegetation patterns.



August 27, 1969. A difference in lighting and lenses hinders interpretations. Nonetheless, it is apparent that the character of the tall forb vegetation remains essentially unchanged.



**Figure 19.** Fish and Wildlife Service photo #22-WB-34027 by O. Murie. July 24, 1928. Elevation 9500'. Tall forb, elk summer range, at the head of Rodent Creek near Wildcat Peak.



**August 28, 1969.** Differences in lighting and lenses limits interpretation of herbaceous cover. A decrease in elk occurrence is suggested by decrease in number of trails and impact thereon.



Figure 20. USGS photo #117 by T. Jagger. September 4, 1893. Elevation 10,100'. Looking southeast on Continental Divide at headwaters of Marsten Fork of South Fork Shoshone River. Soils are silt loam derived from braccia parent material.



September 10, 1968. Difference in film and lighting does not allow contrast in vegetation. Close inspection shows an increase in the principal sedge cover. Current elk use in this locality is minimal.



Figure 21. USGS photo #57-HS-1219 by W. H. Jackson. 1872. Elevation 9200'. A view down Miles Canyon and up the South Fork of Teton Canyon. A tall forb community occurs in foreground.



August 5, 1969. Developmental stage of tall forb vegetation is more advanced than in 1872 scene. Site potential is limited by shallow soil and high occurrence of surface rock. Retake suggests no significant change in ground cover.

**Short-Term Measurements**—Short-term measurements of vegetation and litter were made by estimates in .96 square foot plots (Fig. 8). Measurements from two of three transects inside the Big Game Ridge enclosure suggested improvement in vegetation and litter, while the third transect indicated no significant change. Of the two transects outside the enclosure, number 1 suggested vegetational variations with slight improvement over the first measurement. Transect 2, situated on a much more productive site, suggested an improved vegetation and litter cover. Measurement differences in Figure 8 are not believed to be totally indicative of short term vegetation and litter changes as they could easily be attributed to individual variations in production, date of measurement and covering of vegetation by gophers.

Short term photographic evidence suggests no significant change in the vegetation inside or outside the Big Game Ridge enclosure after 11 years (Fig. 22). The August 15, 1967, photo shows a contrast in vegetative cover due to elk utilization and trampling. Impact immediately adjacent to the enclosure is accentuated by horses used by inspection teams and the influence of the fence which tends to direct movements of elk along the fence. The July 14, 1971, photo shows the vegetation outside (left) and inside (right) before grazing. It is readily apparent that the vegetative density outside is comparable to that inside the enclosure.



Figure 22. Vegetative conditions at the Big Game Ridge enclosure on August 15, 1967 (left), and July 14, 1971 (right). Grazed range is on left in both photos.

# BIOTIC INFLUENCES ON THE VEGETATION

## Elk Foraging

Although many biotic agents influence the vegetation of Big Game Ridge, the elk have been of major concern. Other native ungulates, mule deer (*Odocoileus hemionus*) and moose (*Alces alces*) are found on Big Game Ridge during the summer, but densities are very low compared to elk.

As established in "The Elk Population" section of this paper, elk were making heavy use of Big Game Ridge and adjacent country long before settlement of Jackson Hole. Most investigators of the Big Game Ridge situation appear to have been unaware that Big Game Ridge had been historic elk summer range. They, instead, considered that elk were originally plains animals and had been driven to the mountains by settlement. Some also believed that Jackson Hole was not historic winter range. The picture was further influenced by the idea that supplemental winter feeding, initiated in Jackson Hole in 1912, resulted in winter herd sizes larger than those which occurred historically, which in turn resulted in unnaturally large herds on the summer range - in excess of the carrying capacity. Deterioration of vegetation was believed to be the end result (Beetle, 1952). A review of historical narratives suggest that these premises were incorrect.

There is no indication of a concern over forage utilization on Big Game Ridge or adjacent ranges during early years. Graves and Nelson (1919) alluded to this area as being ideal summer range and having long been the resort for a great number of elk. Bailey (1915) provides the first qualitative evaluation by a biologist of forage utilization on Big Game Ridge. His field notes of August 19, 1915, describe elk foraging as follows:

"In places where the big herd was feeding (study area at the headwaters of middle fork and west fork of Wolverine Creek), the grass showed evident signs of having been grazed, but there was still abundance in the most grazed spots. No discrimination in kinds was noticed and the sedges (*Carex* and *Luzula*) were also eaten. Wild timothy and redtop were abundant on the slope, but seemed not to be specifically sought out."

Bailey and Simpson (1915) further describe the elk summer range situation in these terms:

"The summer range of elk, both in and around Yellowstone Park is fortunately ample, not only for the present herds, but for many times their number. Certainly 100,000 elk could summer in the Yellowstone Park and as many more outside toward the south. Even where they were most numerous and the ground well tramped by their footprints, the grass and native plants were full of flowers and seeds and showed almost no signs of grazing. In a few spots on Big Game Ridge, the Two Ocean Plateau, and Cliff Creek the elk herds had remained long enough in the same locality to make some impression on the amount of grass, but in no place was one-half of the forage utilized."

More recent investigations have concluded that the sparsely vegetated exposures on portions of Big Game Ridge formerly supported a better vegetative cover. Beetle (1952) reasoned that the elk preferred the south slopes which were the most susceptible to overgrazing. Croft and Ellison (1960) came to a similar conclusion in stating: "destruction of vegetation and soil on that part of Big Game Ridge. . . is largely a result of excessively heavy use by elk. Apparently much use occurs in the spring when only the windswept ridges are free of snow and before any notable plant growth has occurred." Anderson (1958) also came to the same conclusion.

Seven years of aerial and ground observations have established that the first arrivals of elk at the higher elevations on Big Game Ridge usually occur during the first week in July (Table 4). Although the soil surface is largely bare of snow, elk distribution is principally below 9,600 feet in elevation. Only a few small scattered groups frequent the study area at this time.

Table 5 demonstrates that elk foraging in quadrats is light through the second week in July. Herbage removal up to this time was almost entirely confined to the terminal ends of a limited number of species per quadrat where foraging had occurred. This finding does not support the idea of some past investigators that early season foraging by elk, particularly adjacent to snowbanks, had caused a deterioration of the grazable vegetation.

Utilization by elk increases in the latter part of July with rising temperatures and the occurrence of molesting insects at the lower elevations. The cumulative forage use has not reached the peak, however, as elk numbers are just beginning to attain maximum levels.

Mid-summer inspections suggest elk frequent all aspects by the first week in August. Virtually all quadrats show some level of forage removal by this time. Utilization by volume of usable forage is variable depending on the year.

Table 4.—Distribution of majority of elk by elevation, Big Game Ridge<sup>1</sup>.

Date	8600'- 9600'	Above <sup>2</sup> 9600'	Observ. Method	Source
July 14, 1965	X		Ground	Yorgason (Per. comm.)
July 23, 1965		X	Aerial	" "
July 29, 1966		X	Aerial	" "
July 11, 1967	X		Ground	" "
July 17, 1968	X		Ground	" "
July 30, 1968		X	Aerial	" "
Aug. 15, 1967		X	Ground	Gruell & Yorgason
June 18, 1968	X		Aerial	Gruell (This study)
July 23, 1968	X		Ground	" "
Aug. 6 - 8, 1968		X	Ground	" "
June 24, 1969	X		Ground	" "
July 23, 1969		X	Ground	" "
Aug. 12-13, 1969		X	Ground	" "
July 16, 1970	X		Ground	" "
Aug. 4, 1970		X	Ground	" "
June 25, 1971	X		Aerial	" "
July 14, 1971	X		Ground	" "

<sup>1</sup>Numbers of elk observed similar to Table 1.

<sup>2</sup>Majority of elk at or above 9600 feet. Periodic movement to elevations under 9600 feet does occur when the elk are watering, feeding, or when disturbed.

Table 5.—Elk foraging, tracking and relative abundance on 18 quadrats 1969 - 1971.

Date	No. Quadrats Showing Elk Foraging	Estimated % of Forage Consumed	No. Quadrats With Tracks	Mean No. Tracks	Range
July 8-9, 1969	2 (1)*	Trace	3	.7	2 - 7
July 23, 1969	12	3%	17	7.9	1 - 21
Aug. 12-13, 1969	17	10%	1	(Washed out by rain)	
July 16, 1970	4 (1)*	Trace	6	.6	1 - 3
Aug. 4, 1970	18	18%	17	8.8	2 - 20
July 14, 1971	1 (4)*	Trace	0	0	0

\*Number of quadrats snow covered and unavailable to elk.

The summer of 1970 proved to be the high point of grazing pressure. On August 4, Range Conservationist, Tom Phillips, estimated 18% utilization by volume in the 18 quadrats. Estimates of utilization by volume in September were considered arbitrary because of the cured and matted condition of the vegetation. Recognizing this limitation, an estimate of 31% utilization by volume was made on 40 - .96 plots on September 17, 1970.

Use transects of 200 - 300 plants were also run in September from 1967-71 by the Wyoming Game & Fish Commission Biologist (Table 6). Sampling included assorted grasses and mountain dandelion plants in the middle fork of the Wolverine Creek study area. Over the five year period an average of 16 dandelion plants were cropped per 100 measured. The high was 18 in 1969. The low was 13 in 1968. Grass use averaged 25 plants used per 100 measured. The heaviest utilization was made in 1970 when 40 plants were used.

Cole (1969) and Wood (1972) found from study of adjacent southern Yellowstone Park summer ranges that perennial grasses were taken more readily than forbs in the spring. Sample units on Red Creek Ridge, the most heavily utilized subalpine range studied, showed an average of 39 slender wheatgrass and 34 mountain brome plants grazed during spring; 19 and 9 plants, respectively, were grazed during the summer from 1964-72. Utilization has shown considerable seasonal and annual variation. The level of forb utilization as suggested by sampling mountain dandelion is also quite variable. Sampling over 9 years shows a high of 53 forbs utilized in 1969 and low of 27 in 1968 (Table 6).

Table 6.—Percent of key forage species grazed by elk on Big Game Ridge and Red Creek Ridge, 1964 - 1972.<sup>1</sup>

Year	Big Game Ridge <sup>2</sup>			Red Creek Ridge <sup>3</sup>			
	Mountain Dandelion	Grass & Sedge	Mountain Dandelion	Mountain Brome Spring	Mountain Brome Summer	Slender Wheatgrass Spring	Slender Wheatgrass Summer
1964			31	50	2	58	8
1965			36	25	4	37	12
1966			31	16	2	27	11
1967	14	25	40	44	6	45	14
1968	13	17	27	18	7	23	15
1969	18	27	53	61	11	56	40
1970	16	40		48	21	64	21
1971	17	17	48	26	19	29	24
1972			35	15	11	15	20

<sup>1</sup>Plants tallied as grazed if any portion of the leaves, culms, seed heads showed utilization.

<sup>2</sup>From I.J. Yorgason, Wyoming Game & Fish Commission - Transects sampled 200 - 300 plants in each group.

<sup>3</sup>From Cole (1969), Wood (1972), National Park Service - Transects sampled 300 plants in each group.

This and concurrent studies have shown that the yearly intensity of grazing varies considerably. During wet-cool summers, such as 1968 and 1972, when 8 and 12 elk-days-use per acre were recorded on pellet transects, the elk remain scattered throughout the summer (Table 7). In 1968 and 1972, the forage remained succulent late into the summer and molesting insects had less influence on elk distribution. By contrast, 1970 represented the other extreme as the weather was unusually warm through late August. Observations indicated a greater concentration of elk for a longer period than

usual. This was confirmed on September 17 when the pellet transect showed a high count of 42 elk-days-use per acre. It was evident the elk had utilized the higher elevations where the forage was more succulent and insects less bothersome. According to several ranchers, the horseflies (*Tabanidae*) were more numerous and persisted longer than any time in memory. Cole (1969) relates intensity of summer grazing to abundance of molesting insects. Grazing intensities of 31 elk-days-use per acre in 1969 and 29 elk-days-use per acre in 1971 appear to be a "more normal" level of use.

Cumulative plot inspections have suggested plant species preferred by summering elk include: sky-line bluegrass, mountain brome, slender wheatgrass, sedges, mountain dandelion, asters, fleabanes, fernleaf ligusticum and elephant pedicularis. Of these, the widely occurring asters and fleabanes appear to receive the most consistent use. The spring diet is comprised of a high percent of grasses with a shift to forbs with advancing season.

Table 7.—Relative elk abundance by pellet group counts on 40 1/100 acre plots.

Date	No. Plots With Pellet Groups	Mean No. Pellet Groups Per Plot	Range	Elk Days Use/Acre
August 27, 1968	23	1	1-7	8
Sept. 16, 1969	37	4	1-13	31
Sept. 17, 1970	39	5.5	1-17	42
Sept. 14, 1971	35	3.7	1-16	29
Sept. 20, 1972	21	1.5	1-5	12

The most conspicuous effect on vegetation for which elk are primarily responsible appear to be disclimax situations on localized exposures. This vegetation is usually restricted to ridges where elk have habitually bedded and has also been reported to occur in southern Yellowstone Park by Cole (1969). As a consequence of continued use, the composition of these small areas is predominately a mat-like cover of varileaf cinquefoil and western yarrow. These species form an excellent protective ground cover. In view of a history of elk occurrence there is good reason to believe this condition existed in pristine times, is an expected biotic influence, and is not considered a departure from natural conditions.

Of particular importance is the manner in which Big Game Ridge is grazed. Because of the annual variation in the nature of the grazing, plants cropped one year may go unused the following year and as a result, a substantial quantity of forage is left untouched. In essence, a complex deferred rotation grazing system evolved. As a rule, grazing removes only a small portion of the vegetation. Repeated quadrat observations show a light cropping of less than half of the plant. Following flowering, herbage removal from forbs tends to be confined to flower heads. At a comparable growth stage, the use of grass is minimal. The likelihood of unnatural plant losses under current levels of utilization is remote (Fig. 22). This likelihood is further diminished when one realizes that a significant percent of the plant cover reproduces vegetatively. Other studies suggest that some plant species might be lower in vigor than would be the case were they growing on ungrazed range. Muggler (1967) found that one clipping of *Aster integrifolius* and *Potentilla gracilis* at a 4 cm height, just before and during flowering, caused a 50% reduction in herbage production and a 80% reduction in flower stalks. In this instance, the clipping intensity could be likened to severe grazing - a condition that does not exist on Big Game Ridge. The clipping of three grasses - *Festuca idahoensis*, *Bromus marginatus* and *Agropyron trachycaulum* was generally most harmful in late July and August, from flowering to seed ripening. Removal of herbage either during early growth or after the foliage began to dry did not damage either the forbs or grasses appreciably.

#### Trampling and Tracking

The occurrence and effect of elk trampling and/or tracking was followed through periodic inspection

of permanent quadrats and repetitive observations in the general area (Table 5). Particular emphasis was placed on early season observations, as this was the time when damage was believed to occur (Croft and Ellison, 1960).

Repeated observations showed the most concentrated trampling to be confined to a locality on the east slope of the separating ridge between the west and middle forks of Wolverine Creek. The disturbed area was confined to a narrow strip several hundred yards in length, (approximately 3 acres) below a melting snowbank at about 9,500 foot elevation. The locality appeared to be the focal point of early elk activity as groups of 200 or more elk were observed nearby on several occasions. As the degree of trampling was the exception, it is believed to be solely the result of a terrain preference coincident with good forage. Elk show a preference for snowbanks during hot days, during periods of insect activity and as sources of water in late summer. Trampling results from routine travel at a time when the saturated soil surface is susceptible to tracking.

Another area of comparable trampling was on the northeast side of the pass separating the middle fork of Wolverine Creek from a tributary of the Snake River. This site was reported upon by Croft and Ellison (1960) and is an extreme situation as the main migratory trail crosses a late melting snowbank. Total area trampled was estimated at one acre.

Various degrees of tracking intensity were observed, and varied from widely occurring tracks on dry soils with several feet between tracks to local areas with a high intensity of tracking around late melting snowbanks. The most intense tracking always took place in August when the animals were more concentrated and soils were dry. Three years reconnaissance of the area and inspection of permanent quadrats showed that except for certain preferred snowbanks where tracking was heavy, tracking through mid-July was insignificant. Fifty-four cumulative quadrat inspections on July 8-9, 1969, July 16, 1970, and July 14, 1971, showed tracks occurring in but seven quadrats. These quadrats sampled a wide variety of sites and results demonstrated that elk impact through trampling is negligible during the early stages of vegetal development.

Observations made during this study suggest that elk trampling of the soil surface on Big Game Ridge does not occur during a period when the watershed is vulnerable to trampling damage and trampling itself is not of sufficient intensity or extent to cause such damage. Of primary importance is a soil surface with a low clay content which is not subject to compaction damage. The limited areas showing intense tracking are considered to be a natural biotic effect.

### **Pocket Gophers**

In earlier studies on Big Game Ridge, Laycock (1953), Croft and Ellison (1960), and Diem and Kennington (1963) found pocket gophers numerous as evidenced by winter casts, mound counts, and trapping. Dense populations are not unusual for high elevation forb ranges in Utah, Colorado and elsewhere in the west (Richens, 1965 and Colorado Cooperative Pocket Gopher Project Committee, 1960). From a 1961 inspection of Big Game Ridge, it was concluded that prevailing pocket gopher - vegetation relationships were comparable to the Grand Mesa of Colorado (A. L. Ward, pers. comm. 1971).

It seems certain that pocket gophers were numerous in various forb communities of the Yellowstone Park - Big Game Ridge region prior to settlement of Jackson Hole. Jones (1875), while traveling horseback through Yellowstone Park in the vicinity of Pelican Creek states:

"This country is the home of great numbers of field mice and moles, which have burrowed up the ground to such an extent that it is traveled over with difficulty. The same is true of a great deal of the open country in the Yellowstone Basin."

On Warm Spring Creek, Jones comments:

"The country along this creek for about eight miles from the Yellowstone River, is an open rolling prairie, extensively burrowed by moles and gophers."

Ingersoll (1883), describing his experiences on the Hoback drainage while with the Hayden Survey of 1877 states:

"Wherever the snow was gone, we saw that this soil was thrown up into innumerable ridges by the moles, which had tunneled under the snow in every direction".

Ingersoll and Jones had mistaken the winter workings of pocket gophers for moles, which are relatively scarce in western Wyoming, or used the common name "mole" for the gopher.

The net influence of pocket gopher activity on high elevation summer ranges has been under investigation for the past 50 years. Findings are divided between those who believe the gopher to be "beneficial" to the range and those who believe him to be "harmful". Grinnell (1923 and 1933) and Taylor (1935) found that pocket gophers are a necessary part of nature's economy, deepening and fertilizing the soils and checking erosion. Ellison (1946) concluded they were an important agent in the process of soil formation and normal geologic erosion on subalpine grassland. Gophers were found to greatly increase accelerated erosion once this process was set in motion on ranges denuded by excessive livestock grazing. In a later study, Ellison and Aldous (1952) found that removal of vegetation by gophers was not sufficiently high to cause accelerated erosion. Over an eight year period, the trapping of gophers from an exclosure did not significantly influence an increase in the vegetation.

Day (1931), Gabrielson (1938) and Peck (1941) considered the pocket gopher a prime cause of accelerated soil erosion on mountain lands. Turner (1969), working on the Grand Mesa of Colorado, found an increase in forb production (exclusive of sneezeweed) of 258 pounds per acre between 1941 and 1951 which he attributed to the removal of gophers. Julander et al. (1969) report that pocket gophers were responsible for a marked decrease in grass production on a seeded Utah range.

Data on pocket gopher occurrence, season of activity and impact on the soils were obtained through observation of soil disturbance within the 3 x 3 ft. quadrats and 1/100 acre plot transect (Tables 8 and 9). Disturbance was recorded in terms of plugs, mounds or lineal feet of winter casts. Mound counts have been used by various investigators to express the relative abundance of pocket gophers (Mohr and Mohr, 1936; Phillips, 1936; Davis et al., 1938; Ellison and Aldous, 1952; Julander et al., 1959; Howard, 1961 and Reid et al. 1966). The recording of winter casts in lineal feet is believed to be a project innovation.

The frequency of winter casts was recorded in the quadrats once yearly between the dates of July 7-16, 1969-71. Results showed 10 of 18, 8 of 17 and 9 of 14 quadrats with several inches to 3 lineal feet of casts during the three consecutive years. Snow cover did not allow the recording of data for all 18 quadrats each year.

Table 8.—Pocket gopher activity by count of casts (winter) and mounds (summer) in 18 quadrats.

Date	Activity	Quadrats With Activity	Estimated Lineal Feet Of Casts	Number Mounds And Plugs
July 8, 1969	Casts	10	20	
July 23, 1969	Mounds	1		1
Aug. 12-13, 1969	Mounds	3		3
July 16, 1970	Casts	8	17	
Aug. 4, 1970	Plugs	1		5
July 14, 1971	Casts	9	17	
Sept. 14, 1971	Mounds	2		5

Table 9.—Fall pocket gopher activity by mound counts in 40 1/100 acre plots.

Date	Plots With Activity	Mean No. Mounds Per Plot	Range	Total Mounds
Sept. 16, 1969	27	6.7	2 - 28	268
Sept. 17, 1970	26	6.0	1 - 35	242
Sept. 14, 1971	20	3.0	1 - 16	118

Further evidence of the high frequency of winter disturbance is indicated by the recording of approximately 598 lineal feet of winter casts in 40 - 1/100 acre plots on July 16, 1970. Only two plots failed to show any casts, while 38 averaged 15 lineal feet per plot. Since plots fell at a 2 chain interval over a contoured transect of about one mile, they are believed to represent an objective sampling of winter soil disturbance in the study area.

Reid et al. (1966) cite other workers as finding that mid-summer digging activity by pocket gophers is minimal. Mound and plug counts made in quadrats between late July and mid August concur with these findings. Only five quadrats in 54 samplings showed recent mounds or plugs. Inactivity during the summer has been attributed to the raising of young (Reid et al. 1966; Ellison and Aldous, 1952).

Fall gopher mounds were recorded but once in the quadrats. Instead, mound counts of recent origin were made in the 1/100 acre plots over the mile transect. Results for September 16, 17 and 14, 1969-71, showed 268, 242 and 118 mounds and plugs respectively in the 40 plot yearly samples. The 1971 count is believed to be minimal owing to dispersion of soil surface by precipitation, thus making mounds to appear as old sign and uncountable. The high count for any one plot was 35 mounds, while the average was 6.7, 6 and 3, respectively, during the three year period. Of particular note, was the tendency for mounds to be more prevalent on the east half of the transect. Between two-thirds and three quarters of the activity was in this segment. This finding supports general observations that gophers tended to concentrate their activities in localized areas, particularly on southern exposures and snowbanks.

Stoney-shallow well drained soils low in production of vegetation were also extensively worked by pocket gophers (Figs. 3 and 4). Douglas (1969) found a similar situation on the Mesa Verde National Park in Colorado. Here one of the largest gopher colonies occupied a rocky ridge where there was difficulty obtaining soil samples at 6-12 inches.

No attempt was made to census the current gopher population by mound counts as the effort required did not seem justified for purposes of this investigation (Reid et al., 1966). In their earlier study, Diem and Kennington (1963), by means of mound counts on belt transects, report a late summer population of 101 and 102 gophers per acre in 1962 and 1963 on Big Game Ridge. These population figures are considerably higher than has been reported in other population studies; if accurate, they must represent extreme population highs. Studies by Ellison and Aldous (1952) and Richens (1965) suggest that populations of 33-39 gophers per acre have occurred on high elevation Utah ranges. The Colorado Cooperative Pocket Gopher Project Committee (1960) reports fall populations of 22 per acre are not unusual on forb ranges of the Grand Mesa.

The relative impact of pocket gophers on the soil surface can be better appreciated when one realizes the amount of soil that can be moved in a year's time. Ellison (1946) estimated a displacement in the neighborhood of 6-1/2 tons per acre. Grinnell (1923) working with *T. monticola* in Yosemite estimated that winter soil displacement alone accounted for nearly four tons per acre. On the Grand Mesa of Colorado, it was found that the amount of soil removed from a burrow system by one gopher may consist of three tons. One gopher may have a burrow system consisting of more than 500 feet (Colorado Cooperative Pocket Gopher Project Committee, 1960).

Quantative data on soil moved per acre were not obtained. It is reasonably certain it would be comparable to that found in other studies and the important point is - how much of the soil surface is

disturbed by gophers? A good indication was provided by seven inspections of the 18 quadrats over three years (Table 8). Three of the 18 quadrats were completely free of gopher disturbance. It should be noted that fall observations were made but once. The other 15 quadrats were disturbed at least once during the period. Four received yearly winter displacement of soil, while six showed fresh casts two winters out of three. Figure 23 shows an example of concentrated winter activity. The data suggested that five times out of six, every nine square feet of the soil surface on randomized sites might be disturbed by gophers in the course of three years. This estimate appears conservative since it does not fully allow for mounds made during the fall. Over longer periods this estimate could be expected to vary considerably as gopher populations fluctuate.



Figure 23. High occurrence of winter gopher casts typical of local areas showing concentrated activity. July 14, 1971.

The net influence of a high degree of soil disturbance on the plant cover has been discussed by Laycock (1958). His study of valley sites in the north end of Jackson Hole showed that gopher mounds provide an ideal seedbed for therophytes (pioneer annual species) and that these species comprised the predominate vegetation on mounds. Winter casts also provide an ideal seedbed for therophytes. Considering the great quantity of soil that is turned up in mounds and casts yearly, it is concluded that therophytes have been and will continue to be a significant part of the plant composition on Big Game Ridge.

Whether or not the present degree of soil disturbance by gophers is "harmful" or "beneficial" should be tempered with the perspective that gophers, elk and the rest of the fauna have evolved with the vegetation and that consistently harmful relationships would have been eliminated through natural selection. Close inspection of Figure 12 suggests that gopher disturbance has been of common occurrence for nearly 60 years on Big Game Ridge. Laycock (1958) also discusses the influence of gopher

mounds through coverage of vegetation. He found that the hemicryptophytes (stoloniferous plants), being more adaptive to revegetating after being covered, represented the greatest number of individual plants growing through the mounds. A high percentage of the plant cover on Big Game Ridge is composed of hemicryptophytes. It follows that covering of the vegetation is but a temporary disruption of plant growth on mound microsites. In time the cover is restored on the mounds by reorientation of bud ends and establishment of seedlings.

As cited previously, gophers consume a significant amount of forage yearly. Ward and Keith (1962) report that 93% of the gopher's summer diet was forbs on a range consisting of 50% grasses, 42% forbs and 8% shrubs. Some 74% of the material was stems and leaves, while 20% was roots. Roots and tubers are taken in greatest amounts in winter (Colorado Cooperative Pocket Gopher Project Committee, 1960). An important winter food item on Big Game Ridge, as suggested by food caches, are spring beauty bulbs. As this species comprises a principal part of the plant composition on snow banks, its use might in part, account for the heavy occurrence of winter casts on snow banks.

Field observations suggest that gopher population densities fluctuate widely on Big Game Ridge (Yorgason, 1967 pers. comm.) and are similar to situations found on the Grand Mesa (Colorado Cooperative Pocket Gopher Project Committee, 1960). Major die-offs appear to cause the radical population changes as found by Reid et al. (1966) and Julander et al. (1969). When populations are high, the soil surface is subjected to widespread disturbance. During these intervals, the terrain takes on a more denuded look, owing to the high incidence of disturbance.

The gopher's principal effect appears to be in perpetuating bare soil openings and maintaining localized sites in an early successional stage. This influence has not been fully appreciated by some investigators since observations were usually made in mid-summer at a time when activity was at a low. As a consequence, mounds of the previous year and winter casts were not readily discernible, having largely been obliterated by plant growth, precipitation and elk tracking.

## DISCUSSION AND CONCLUSIONS

Review of the literature indicated that Big Game Ridge was an important elk summer range long before settlement of Wyoming. The population levels prior to settlement are unknown, but were much in excess of the current population. The historic winter range for the summer elk population on Big Game Ridge was Jackson Hole valley and the Buffalo, Spread Creek and Gros Ventre tributaries of the Snake River. Heavy losses during severe winters were responsible for greater fluctuations in the population than in recent years. The literature review did not support the popular belief that winter feeding allowed population increases on the winter range which resulted in deterioration of the grazable vegetation and watershed of Big Game Ridge.

The high elevation of the Big Game Ridge summer range subjects it to a wide range of weather extremes. Snow can fall during any month but usually occurs between early September and late June. A more or less continuous snowcover through the third week in June usually inhibits plant growth until the first week in July. Snow banks persist on many sites through the third week in July. The prevailing climate is harsh as indicated by an estimated annual mean temperature of 21°F. Heavy frosts can occur at anytime during the summer months. All things considered, the severe climate is a significant deterrent to optimum plant growth.

Big Game Ridge is geologically young and is comprised of a thick succession of sandstone, conglomerate, tuff, claystone and shale. These parent materials do not appear to have elemental deficiencies.

Soils studies suggest that soils are not deficient in nutrients nor do they contain excessive salt concentrations. Controlled experiments indicate that soil fertility is not a limiting factor in plant growth on lightly vegetated areas. A soil pH ranging between 5.0 and 6.5 in the top 18 inches of the soil surface suggests that pH is not a limiting factor in soil productivity.

Soil pits showed that soil texture and moisture holding capabilities vary considerably. Since sparsely vegetated sites are invariably underlain by shallow-cobbly soils and/or sandy materials, there is good reason to believe that growth potential is limited by a reduction in the effective rooting depth and rapid drying of the soil surface. Where snowbanks persist, harsh microclimates appear to be the primary deterrent to the development of dense plant cover. Plant productivity is high where soils are deep loams underlain by clay. Productivity is directly related to soil depth and moisture availability.

This author's interpretation, in light of new information, suggests today's watershed conditions on Big Game Ridge are not unlike those of 100 years ago. Prevailing hydrologic conditions are considered to be a natural phenomenon, being primarily the product of geologic processes. These processes do not appear to have been accelerated by man's settlement of lower valley areas.

Past evaluations of watershed conditions appear to have been lacking in historical perspective. The use of standard indices such as erosion pavement in measuring condition also may have misled some observers. This indice has proven reliable when studying conditions on abused livestock ranges. It may need to be interpreted much differently when applied to historic game range. The presence of erosion pavement on Big Game Ridge is not considered to reflect accelerated soil losses. Rather, the gravel occurring in the soil profile is continually being exposed to the surface, primarily by pocket gopher activity, and is not the result of disturbance by elk concentrations.

Fire is considered to be a natural influence on the watershed and presumably the vegetation has evolved to contend with periodic fires just as it contends with other biotic and abiotic influences.

The vegetation of Big Game Ridge is primarily an "herbland" or tall forb community. Of the seventy plants collected, 14 were grasses, sedges or rush, 55 were forbs and only one was a shrub. Measurements of vegetation in this and adjacent areas showed that forbs dominate the plant communities.

Four years' data suggest vegetal development at the 9,600 foot elevation essentially begins on the southerly aspects during the first week in July. At infrequent intervals, emergence may vary 10 days earlier or later. Despite variations in emergence, peak development of the majority of species is reached around the first week in August. The growing season is short, being about 30 days. Heavy frosts occur which help to inhibit optimum growth some years. Yearly production is variable depending upon prevailing soil moisture and air temperature during the growth period.

After putting the conditions of the vegetation in historical perspective with known events and conditions, my interpretation is that the present condition and successional trends are not considered to represent departures from natural conditions. Photographic evidence provides strong support for this interpretation. The pertinent fact is that a significant deterioration in the plant cover has not occurred since 1915, the point past which settlement of the Jackson Hole region might have had a potential to upset the balance between the elk and their summer habitat. The evidence supports an improvement in range conditions following 1915. Photos from 1872-1893 on other high mountain summer ranges suggest the same trend.

Data from the 18 quadrats and stratification of pellet transect data have demonstrated that the intensity of forage utilization is related to the relative productivity of the site. With little exception, the better producing sites attract the greater utilization while the poor producing sites receive light use. The sparsely vegetated sites of low productivity are neither sought out early, nor are they habitually utilized throughout the summer. These sites have a limited attractiveness to elk and are grazed accordingly.

In summation, measurements from this and other studies suggest that forage utilization on Big Game Ridge has not been excessive. Data indicate that adequate herbage is left to manufacture the food needed for plant growth and reproduction. Had this not been the case over the years, the vegetation trend indicated in Figures 12 - 17 would be downward rather than upward or unchanged.

No information has been found which suggests an increase in tracking incidence which might account for watershed "deterioration". The trend instead has probably been one of reduced tracking with a decreasing elk population. The area is and has been an ideal summer habitat for elk. As such, it has and will continue to receive tracking and trampling at various intensities depending upon yearly weather and the elk population level. As tracking is inherent and inevitable, it should be accepted as a natural biotic effect.

The combined evidence indicates that high pocket gopher populations on Big Game Ridge are a by-product of range condition rather than a cause, and do not represent a departure from natural conditions. These rodents are closely associated with a tall forb community which is conducive of supporting high populations. This relationship has doubtlessly prevailed for centuries. Support for the contention that pocket gophers have brought on accelerated erosion through destruction of the plant cover has not been found. Their primary contribution to natural rates of erosion has been to expose the soil surface to the elements. This habitual exposure of the soil surface has also been a significant contribution to the denuded appearance of lightly vegetated sites.

In retrospect, the Big Game Ridge syndrome might be summed up as follows:

The impression an individual gains upon visiting Big Game Ridge is apprehension concerning the condition of the watershed. It is in "poor hydrologic condition" when the usual criteria are applied. The locally sparse ground cover, erosion pavement, plant segments and incised gullies suggest that something is out of balance. The prevailing condition has a superficial resemblance to various domestic sheep ranges in the west, although the ridge has never been grazed by livestock.

Despite these indicators of "habitat deterioration", one is forced to question whether the harsher appearing areas of the watershed were ever capable of supporting a vegetal cover more lush than that at present. Extended observations soon suggest that strong abiotic limitations to plant establishment and production occur at various sites. The added advantage of observing other high elevation ranges in the Teton Wilderness and Yellowstone Park region in combination with the availability of historical photos makes one soon appreciate that sparsely vegetated localities are not the end product of overgrazing. As this region approximates pristine conditions more closely than anywhere in the nation, it becomes evident that "poor ground cover" and raw appearing watercourses are geologically and climatically determined and are inherent to this region. Those who have not had an opportunity for extended observations have been at a distinct disadvantage in evaluating conditions on Big Game Ridge.

## RECOMMENDATIONS

1. It is recommended that the Big Game Ridge and Gravel Creek exclosures be dismantled. These structures have served a useful purpose in providing sites where ungrazed range could be compared to grazed range. Heavy snow loads have badly deteriorated the Big Game Ridge exclosure, making upkeep prohibitive. Considering study findings, maintenance costs, and wilderness management direction, the continued upkeep of these facilities is unjustified. Removal of the exclosures should be coordinated with the University of Wyoming to prevent loss of study data.
2. It is recommended that no consideration be given in the future to contouring, seeding, or gully plugging watershed improvement practices. Any manipulations of this nature are not in keeping with the Wilderness Act. This study has demonstrated that watershed conditions on Big Game Ridge are natural - geologic rather than man-induced. Management direction should be one of recognizing a natural condition and treating it accordingly.
3. It is recommended that the pellet transect be measured each September. Continued sampling will be invaluable in establishing variables in yearly elk utilization on Big Game Ridge.
4. Quadrats and camera points should be rephotographed at periodic intervals for purposes of further documenting differences between short term change and long term trend.

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# APPENDIX I

## Summary of elk reports prior to 1900, Big Game Ridge Region

Source	Date	Report
Russell, Haines (1955)	August 19, 1836	North shore of Yellowstone Lake. "This valley is interspersed with scattering groves of tall pines forming shady retreats for the numerous Elk and Deer during the heat of the day."
		"It being very difficult to get around these places, we concluded to follow an elk trail across it for about half a mile. . . ." ". . . we killed a fat buck Elk and camped. . . ."
	August 6, 1837	Vicinity of Hoodoo Basin. ". . . with the scattered flocks of Sheep and Elk carelessly feeding or thoughtlessly reposing beneath the shade. . . ."
		"I descended to the camp where I found my companions had killed a fat Buck Elk during my absence. . . ."
	August 12, 1837	East of Yellowstone Lake. "We hunted the branches of this stream (Shoshone River) then crossed the divide to the waters of the Yellowstone Lake where we found the whole country swarming with Elk we killed a fat Buck for supper and camped for the night. . . ."
	August 29, 1839	North shore of Yellowstone Lake near present Fishing Bridge. "(the indians) Then commenced shooting at a large band of elk that was swimming in the lake killed 4 of them dragged them to the shore and butchered them which occupied about 3 hours."
	August 29, 1839	". . . game was very scarce on the West side of the Lake. . . ."
Doane (1875)	August 29, 1839	West Thumb of Yellowstone Lake. ". . . a Doe Elk came to the water to drink and he killed her. . . ."
	August 30, 1839	South shore of Heart Lake. "We traveled along the Shore on the south about 5 miles in an East direction fell in with a large band of Elk killed two fat Does and took some of the meat."
	August 29, 1870	South slope of Mount Washburn. "The ground was everywhere tracked by the passage of herds of elk and mountain sheep. . . ."
	September 1, 1870	Between Hellroaring Creek and Lamar River on northeast side of Yellowstone River. "Elk were feeding in small bands on the other side of the valley . . . ."
	September 6, 1870	Inlet of Yellowstone Lake. "The ground was trodden by thousands of elk and sheep."
	September 7, 1870	Southeast side of Yellowstone Lake. "After traveling some distance I discovered we were following a band of elk, having missed the trail in the dark-

Source	Date	Report
		ness. We then struck out for the lake shore, on which our course was regained, but presently lost again after more elk."
	Late September, 1870	Region of Snake River below and in vicinity of Heart Lake. "They (men looking for Everts) found game plentiful and tame, and had no difficulty in obtaining an abundant supply."
		In region of Heart Lake. "Herds of game passed by him during the night, on many occasions when he was on the verge of starvation."
Barlow (1872)	August 16, 1871	Two Ocean Plateau. "Signs of game abound, among which were found tracks of the grizzly and the black bear, mountain sheep, elk and deer."
	August 25, 1871	North of Steamboat Springs on northeast shore of Yellowstone Lake. "On leaving the open valley the wood abounded with game tracks, several elk and deer being seen just in advance of our train."
Bradley (1873)	September 12, 1872	Along upper Snake River narrows between Chicken Ridge and north Big Game Ridge. "To avoid traveling in the bed of the stream, we followed some of the numerous game trails, which led us to from 300 to 400 feet above its level. . . ."
	September 13, 1872	Big Game Ridge. "This is mostly fine grazing ground, and the numerous game-trails give evidence that it is frequented by deer and elk; indeed, we found two herds of elk, of about 20 each among the groves on the top of the ridge."
Jones (1875)	July 31, 1873	Headwaters of North Fork of Shoshone River. "Elk, deer and trout are abundant."
	August 6, 1873	Near Steamboat Springs on northeast shore of Yellowstone Lake. "My camp was upon a well-worn game-trail, which led up a bluff within a few feet of the fire."
		"This locality seems to be a favorite resort of many animals. Our train approached it by following a prominent game-trail, at least a dozen of which, extending for miles into the forest, meet at this point. Upon my first visit to this place, the day before the passage of the train, fresh tracks and other unmistakeable signs of their presence were visible. Today I started numbers of elk while passing through the fallen timber, not far from, some active boiling springs."
	September 1, 1873	Yellowstone River some ten miles above the outlet into Yellowstone Lake. "While the advance was quietly following a first rate trail, it was suddenly observed to lead up to a high hill to our right. I sent an Indian to see what became of it up there, who came back with the information that it had led to an open rocky place on top, and was after that "kaywut", (played out).
		It now appeared that the top of the hill was used as a stamping-ground for elk, and they had made

Source	Date	Report
		such a broad trail leading up to it as to completely deceive us."
	September 2, 1873	Yellowstone River some 23 miles above the inlet into Yellowstone Lake. "All through this basin game-tracks have been very abundant, but our party from its size makes a good deal of noise, which will account for the fact that we did not see a great deal. A magnificent elk crossed the valley in advance of us, and in plain sight to-day."
	September 3, 1873	In vicinity of Two Ocean Pass. "While the small advance party were approaching camp two of our indians discovered three elk close by gave us an illustration of skillful hunting by crawling up and killing the three with four rifle-shots."
Doane (1877)	October 23, 1876	Several miles above Cascade Creek. ". . .and saw that I had ridden close up to a herd of at least two thousand elk. They had been lying in the snow, and. . ."
	October 29, 1876	Heart Lake vicinity. "After resting an hour we preceeded, till long after dark, when we reached the first hot spring basin a mile from Heart Lake. Driving out a large herd of elk resting there, we went into camp."
Jackson (1929)	September 1878	Headwaters of Buffalo River. "It was a fine grassy country, and there we saw great troops of elk forsaking these high feeding grounds for lower altitudes in Jackson Hole."
Hague (1893)	1880's - 90's	Southern Yellowstone - Teton Wilderness. "In winter they descent to the broad valley-bottoms, where food is accessable and shelter easily obtained. In traveling over the country about these feeders to the Snake, I have been impressed by the apparent absence of elk, yet the first heavy autumnal snow will drive them from the mountains to the low lands, the freshly fallen snow being tramped down by hundreds of elk tracks coming from all directions. In the more rugged portions of the country along the summit of the ridges, elk are seldom seen, although well-worn trails traverse the passes of the range at high altitudes, and may be safely followed by travelers as the easiest routes across the mountains." "In an unexplored country, elk trails afford the best means of travel; they are well laid out. . . ."
Roosevelt (1893)	September, 1891	In present Teton Wilderness between south entrance of Yellowstone Park and Two Ocean Pass. "There was not so much as a spotted line - that series of blazes made with the axe,man's first highway through the hoary forest, but this we did not mind, as for most of the distance we followed well-worn elk trails."
		Big Game Ridge. "On the top of the first plateau, where black spruce groves were strewn across the grassy surface, we saw a band of elk, cows and calves, trotting off through the rain."

Source	Date	Report
		Two Ocean Pass area from Two Ocean Plateau. "Far below us, from a great basin at the foot of the cliff, filled with the pine forest, rose the musical challenge of a bull elk; and we saw a band of cows and calves looking like mice. . . ."
		"Here and there we were helped by well beaten elk trails. . . ."
		Two Ocean Pass area. "Woody and I started on foot for an all-day tramp; the amount of game seen the day before showed that we were in good elk country where the elk had been so little disturbed that they were traveling, feeding and whistling in daylight."
		"We roused a small band of elk in thick timber; but they rushed off before we saw them. . . ."
		"He was lying on a point of the cliff-shoulder, surrounded by his cows. . . ."
		Two Ocean Plateau. "Woody and I started to hunt over the great table-land, and led our stout horses up the mountain side, by elk-trails so bad that they had to climb like goats."
		". . .but every now and then send off short, well-worn branches (trails) to some cliff-edge or jutting crag. . . ."
		"Almost immediately we heard the bugle of a bull elk, and saw a big band of cows and calves on the other side of a valley. There were three bulls with them, one very large. . . ."
		"Thirty yards off, behind a clump of pinyons, stood a huge bull, his head thrown back. . . ."
		"The elk I thus slew was a giant. His body was the size of a steer's, and his antlers, though not unusually long, were very massive and heavy."
		"Standing on its brink we overlooked a most beautiful country, the home of all homes for the elk . . . ."
		Two Ocean Pass. "That night, as more than one night afterward, a bull elk came down whistling to within two or three hundred yards of the tents. . . ."
		"The following day I killed another bull elk. . . ."
		"One herd started before he got close, and he killed the master bull by a shot. . . ."
		"As for me, during the next ten days I killed nothing save one cow for meat. . . .It was stormy, with hail and snow almost every day. . . .Our ill success was in part due to sheer bad luck; but the chief element therein was the presence of a great hunting-party of Shoshone Indians. Split into two bands of eight or ten each, they scoured the whole country on their tough, sure-footed ponies."
		"After a week at Two Ocean Pass, we gathered our pack animals. . . .a two-days jaunt took us to the

Source	Date	Report
Brandeggee (1899)	Summer, 1897	summit of Wolverine Pass. . .After three or four days we shifted camp to the mouth of Wolverine Creek, to get off the Hunting grounds of the Indians."
		Coulter Creek locality. ". . .we came on three or four elk. . .We went up the steep, forest-clad mountainside, and before we had walked an hour heard two elk whistling ahead of us. . .they had probably been master bulls. . . ."
		"My aim was true, and the huge beast crashed down-hill. . .His antlers were the finest I ever got." "These two bulls lay only a couple hundred yards apart, on a broad game-trail, which was as well beaten as a good bridle-path."
		"It was a great piece of luck to get three such fine bulls at the cost of half a day's light work. . . ."
		". . .went into camp, by some small pools on the summit of the pass north of Red Mountain. The elk were calling all around us."
		"On this Shoshone trip I fired fifty-eight shots . . . I fire at one as long as it can stand. . .rather than see an occasional head of game escape. In consequence of these two traits the nine elk I got. . . ."
		"Great numbers of elk come down from Yellowstone Park and feed in the high mountains during the summer."

## APPENDIX II

### PLANTS COLLECTED ON BIG GAME RIDGE

Scientific Name	Common Name
<b>Grasses</b>	
<i>Agropyron subsecundum</i> (Link) A.S. Hitchc.	Bearded Wheatgrass
<i>Agropyron trachycalum</i> (Link) Malte	Slender Wheatgrass
<i>Bromus polyanthus</i> Scribn.	
<i>Deschampsia caespitosa</i> (L.) Beauy.	Tufted Hair-grass
<i>Melica bulbosa</i> Geyer	Oniongrass
<i>Melica spectabilis</i> Scribn.	Showy oniongrass
<i>Phleum alpinum</i> L.	Alpine Timothy
<i>Poa epilis</i> Scribn.	Skyline Bluegrass
<i>Poa reflexa</i> Vasey & Scribn.	Nodding Bluegrass
<i>Sitanion hystrix</i> J.G. Smith	Bottlebrush squirreltail
<i>Stipa columbiana</i> Macoun.	Subalpine Needlegrass
<i>Trisetum spicatum</i> (L.) Richter.	Spike Trisetum
<b>Grasslike Plants</b>	
<i>Carex haydeniana</i> Olney	Cloud Sedge
<i>Carex raynoldsii</i> Dewey	Raynolds Sedge
<i>Carex rossii</i> Boott	Ross Sedge
<i>Juncus drummondii</i> E. Meyer	Drummond Rush
<b>Forbs</b>	
<i>Achillea millefolium lanulosa</i> (Nutt.) Piper	Western Yarrow
<i>Aconitum columbianum</i> Nutt.	Columbia Monkshood
<i>Agoseris glauca</i> (Pursh) Raf.	Mountain Dandelion
<i>Antennaria rosea</i> Greene	Rose Pussytoes
<i>Antennaria umbrinella</i> Rydb.	
<i>Arabis lyallii</i> Wats.	Lyall Rockcress
<i>Arnica cordifolia</i> Hook.	Heartleaf Arnica
<i>Arnica longifolia</i> D.C. Eaton	Longleaf Arnica
<i>Aster foliaceus parryi</i> Gray	
<i>Aster foliaceus</i> var. <i>canbeyi</i> Gray	Alpine Leafybract Aster
<i>Aster integrifolius</i> Nutt.	Thickstem Aster
<i>Caltha leptosepala</i> DC.	Elkslip Marshmarigold
<i>Castilleja miniata</i> Dougl.	Scarlet Painted-cup
<i>Claytonia lanceolata lanceolata</i>	Lanceleaf Spring Beauty
<i>Delphinium nuttallianum</i> Pritz.	Nuttal Larkspur

Scientific Name	Common Name
<i>Delphinium occidentale</i> Wats.	Duncecap Larkspur
<i>Descurainia richardsonii</i> (Sweet) O.E. Schultz	Richardson Tansymustard
<i>Draba stenoloba</i> var. <i>nana</i> (O.E. Schultz) C.L. Hitchc.	Draba
<i>Epilobium glandulosum</i> Lehm.	Glandular Willow-weed
<i>Erigeron callianthemus</i> Green	
<i>Erigeron eatoni</i> var. <i>eatoni</i>	Eaton Fleabane
<i>Erigeron ursinus</i> D.C. Eat	Bear River Fleabane
<i>Eriogonum umbellatum</i> (neglectum) Greene	Sulfur Eriogonum
<i>Erythronium grandiflorum</i> var. <i>grandiflorum</i>	Lambstongue Fawnlily
<i>Geranium viscosissimum</i> F. & M.	Sticky Geranium
<i>Hackelia floribunda</i> (Lehm.) Johnst.	Showy Stickseed
<i>Helianthella quinquenervis</i> (Hook) A. Gray	Fivenerve Helianthella
<i>Hydrophyllum capitatum capitatum</i> Dougl.	Ballhead Waterleaf
<i>Ligusticum filicinum</i> S. Wats.	Fernleaf Ligusticum
* <i>Lomatium montanum</i> Coult & Rose	Biscuitroot
<i>Lupinus argenteus</i> var. <i>parviflorus</i> (Nutt. C.L. Hitchc.)	Silvery Lupine
<i>Lupinus wyethii</i> S. Wats.	Wyethia Lupine
<i>Mertensia ciliata</i> (James) G. Don	Mountain Bluebells
<i>Mertensia paniculata</i> (Ait.) G. Don	
<i>Microseris nigrescens</i> Henderson	Microseris
<i>Mimulus lewisii</i> Pursh.	Lewis Monkeyflower
<i>Myosotis alpestris</i> F.S. Schmidt.	Forgetmenot
<i>Pedicularis groenlandica</i> R. Uz.	Elephanthead
* <i>Penstemon whippleanus</i> A. Gray	Whipple Penstemon
<i>Plantago tweedyi</i> A. Gray	Tweedy Plantain
<i>Polemonium pulcherrimum pulcherrimum</i>	Polemonium
<i>Polygonum bistortoides</i> Pursh.	American Bistort
<i>Potentilla diversifolia</i> var. <i>diversifolia</i>	Varileaf Cinquefoil
<i>Ranunculus escholtzii</i> var. <i>alpina</i> (Wats.) C.L. Hitchc.	Eschscholtz Buttercup
<i>Rumex pauciflorus</i> Nutt.	Mountain Sorrel
<i>Saxifraga argusta</i> D. Don	
<i>Senecio crassulus</i> Gray	Thickleaf Groundsel
<i>Senecio triangularis</i> Hook.	Arrowleaf Groundsel
<i>Sibbaldia procumbens</i> L.	
<i>Taraxacum officinale</i> Weber	Common Dandelion
<i>Viola nuttallii</i> Pursh.	Nuttal Violet
<b>Browse</b>	
<i>Ribes montigenum</i> McClatchie	Gooseberry Currant

\* Identified by A. H. Holmgren of Utah State University

# APPENDIX III

## 1968 Soils Information

### Stop No. 1 (Stop No. 3, 1967)

Location: Immediately adjacent to west side of enclosure.  
Exposure: Westerly.  
Slope: 10%  
Erosion: Moderate - 50% of soil surface estimated as bare ground.  
Landform: Glaciated and dissected.

#### 36" Soil Pit

Parent Material: Glacial till from shale, siltstone and sandstone.  
Soil pH: 5.0 - 5.5 in surface layers.  
Soil Texture: Changed from loam and silt-loam near surface to silty clay-loam at 22 inches.  
Permeability: Graded from moderate to very slow with increasing depth.  
Soil Temperature: 56° F. at 1"  
54° F. at 20"  
46° F. at 36"  
Vegetative Cover: Poor - less than 500 lbs. air dry weight per acre.  
Species: Nuttall violet, lance-leaf spring beauty, thistleleaf groundsel, mountain sorrel, western yarrow and wyethia lupine. Small quantities of desirable species present included skyline bluegrass, fernleaf ligusticum and oniongrass. Little difference was detected between the vegetation within and outside the enclosure.

### Stop No. 2 (Stop No. 4, 1967)

Location: Immediately above quadrats 7 -8.  
Exposure: South  
Slope: 15%  
Erosion: Moderate - 80% of soil surface estimated to be covered by bare soil and gravelly erosion pavement of 3/4" to 1".  
Landform: Dissected.

#### 12" Soil Pit

Parent Material: Siltstone and fine grained sandstone. Parent material struck at 12".  
Soil pH: 6.0 in surface layer.  
Soil Texture: Fine to medium subangular structure, friable, 20% gravel on surface and 20% by volume estimated at 3" - 12".  
Permeability: No tests made.  
Soil Temperature: 74° F. at 1"  
56° F. at 12"  
Vegetative Cover: Not described. Compared to previous site cover would be "very poor" with production averaging considerably less (Figs. 3 and 4).

Species: Composition largely scattered occurrence of thickstem groundsel and mountain sorrel-tap rooted plants well adjusted to the site. Other species represented were: wyethia lupine, pale agoseris, Nuttall violet, *Sibbaldia* and Bear River fleabane.

**Stop No. 3 (Stop No. 5, 1967)**

Location: On broad ridge below quadrat 14.  
Exposure: Slightly southeast.  
Slope: 5%.  
Erosion: None. Stable with turf providing effective protection.  
Landform: Saddle on a dissected slope.

**42" Soil Pit**

Parent Material: Sandstone and siltstone.  
Soil pH: 5.5 - 6.5 in surface layer.  
Soil Texture: Loam which varied when wet from very dark brown to dark yellowish brown at 36" - 42". Thin clay film below 36".  
Permeability: No tests made.  
Soil Temperature: 69° F. at 1"  
50° F. at 20"  
42° F. at 42"  
Vegetative Cover: Described as very good with production estimated in excess of 1500 lbs. air dry weight per acre. Most species were in the desirable and intermediate class. Principal species included skyline bluegrass, Nuttall violet, Ross sedge, oniongrass, mountain brome, wyethia lupine and thickstem groundsel.

**Stop No. 4 (Stop No. 6, 1967)**

Location: In lower basin about 1 mile below quadrat 18.  
Exposure: East.  
Slope: 20%.  
Erosion: Moderate sheet erosion. Turf providing effective erosion protection. Soil surface was estimated to be covered by 5% stones. Vegetative and litter cover varied between 20% and 70%.  
Landform: Moderately slumping dissected slope.

**36" Soil Pit**

Parent Material: Shale and siltstone.  
Soil pH: 6.0 - 6.5 in surface layer.  
Soil Texture: Loam which varied when wetted from a dark grayish brown at surface to dark brown at 16". Color was dark grayish brown from 16" to 36". The lower 9" was gravelly siltloam; platy to massive structure; very firm. (Looked like compact shally till or weathered shale or siltstone, compacted from slumping).  
Soil Temperature: 62° F. at 1"  
50° F. at 20"  
46° F. at 36"  
Vegetative Cover: Not described. Productivity was rated high. Pounds air dry weight per acre would average above that of previous site with most species falling into the desirable and intermediate class.

### Stop No. 5

Location: About 100 yards north of Boundary trail and immediately south of scarp on east side of middle fork of Wolverine Creek saddle.

Exposure: South to southeast.

Slope: 5%.

Erosion: Persistent wind erosion prevails when not snow covered. Moderately compacted soil surface from heavy snow cover. Soil surface estimated to be 75% bare.

Landform: Glaciated scoured ridge.

#### 26" Soil Pit

Parent Material: Sandstone parent material struck at 26".

Soil pH: 6.5 in surface layer.

Soil Texture: Varied when wetted from a dark yellowish brown, sandy loam to 17" grading into weathered sandstone.

Permeability: No tests made.

Soil Temperature: 57° F. at 20".

Vegetative Cover: Predominately a sparse occurrence of hummocked Drummond Juncus. Associated species were *Sibbaldia* and Eschscholtz buttercup. Herbage production was not estimated, but averaged below Stop 6 following.

### Stop No. 6

Location: About 100 yards below Boundary trail at the head of the west fork of Wolverine Creek.

Exposure: East.

Slope: 15%.

Erosion: Moderate sheet erosion significantly influenced by wind. (Site has sparse ground cover allowing soil surface little protection). Heavy snow packs had moderately compacted soil surface. Gopher casts numerous.

Landform: Ridge top.

#### 30" Soil Pit

Parent Material: Sandstone.

Soil pH: 6.0 - 6.5 in surface layer.

Soil Texture: When wetted, a dark yellowish brown sandy loam to 19". Below 19" texture graded from a weathered sandstone of loamy sand to a firm sandstone.

Permeability: No tests made.

Soil Temperature: 70° F. at 1"  
47° F. at 20"  
40° F. at 30"

Vegetative Cover: Herbage production estimated at 350 lbs. air dry weight per acre. Principal species included Eschscholtz buttercup, thickstem groundsel, wyethia lupine, elephanthead pedicularis, mountain sorrel, *Carex sp.*, lanceleaf spring beauty, fernleaf ligusticum, skyline bluegrass and hood phlox.



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